Volume 24, Number 9 May 15, 1970

# NUCLEAR SCIENCE ABSTRACTS

## CHEMISTRY

### Analytical Chemistry

*Refer also to abstracts 16545, 17190, 17212, 17249, 17265, and 18035.*

**16408** (JUL-614-RW) ON THE IMPROVEMENT OF THE EMISSION SPECTRAL ANALYTICAL DETECTION POSSIBILITY THROUGH THE USE OF STATIONARY MAGNETIC FIELD ON THE ARC. Lummerzheim, Diethard (Kernforschungsanlage, Juelich (West Germany). Institut fuer Reaktorwerkstoffe). Sep 1969. 112p. (In German). Dep. CFSTI (U. S. Sales Only).

The imposition of longitudinal magnetic fields on direct current arcs causes a rotation of the discharge. The arc rotation rate is strongly induction and slightly current dependent and is 2200 rotations per second at 15 A arc current and 300 gauss. The rotation and a gas current from the cathode to the anode induced by the rotation affects the arc characteristics in the magnetic field: at small induction of about 100 gauss it appears broadened by centrifugal force, at higher inductions it is formed by the preponderant effect of the axial current to a cone at the anode. Because of losses in the magnetic field (resistance increase, cooling) the arc focal voltage is increased. Its sharpest increase lies between 0 and 90 gauss. At about 400 gauss, the focal voltage increase is about 30% for both current intensities with respect to 0 gauss. As a result of an increased energy supply to the magnetized arc, the anode temperature increases: at about 350 gauss for the 10 A arc to 250°K and the 15 A arc to 550°K. The result therefore is an increased anode burnup, which at 15 A current intensity and 320 gauss induction is about 70% over that found without magnetic field. In the 10 A arc an increase of the plasma nuclear temperature was measured additionally by about 150°K over 90 gauss. The $I_L - I_U$ ratios of ion and atomic lines of the most investigated elements were sharply increased in the magnetic field, some by more than an order of magnitude. This occurred by a line intensity increase, which was derived under 100 gauss by a background accentuation and over 100 gauss by a background decrease. The amplification proceeded as a function of the induction in investigated range maxima or discharged at saturation. The $I_L - I_U$ ratios were increased preferably for ion lines generally. A 15-A arc current caused for both line types a stronger increase of the $I_L/I_U$ values than 10 A. The highest increase of an $I_L - I_U$ ratio was found for the ion lines Ca II 3179 at 15 A arc current and 100 gauss. The amplification of the line intensities depended essentially on a complete detection of the evaporated substance by the magnetized arc, an increase of the excitation probability by decrease of the mean free path of the electrons in the axial direction, an extension of the duration of the analysis particles in the excitation zone, and a change of the plasma temperature distribution by the rotation. The background accentuation under 100 gauss was the result of an increased anode disintegration as a result of increased temperature and the concurrent background decrease results from an established axial current, through which the CX molecules (X = C, N, O, etc.) arising from the anode were kept away from the excitation zone. The relative standard deviation of the $I_L/I_U$ individual determinations increased first up to 90 gauss and dropped with additional increasing magnetic field intensity. Without use of a magnetic field, it was 15 to 20% and at about 300 gauss was still about 10%. The reproducible detection of the evaporated substance by the magnetized arc was therefore decisive. The scattering of the background darkening showed the same tendencies as the background darkening itself. At 300 gauss, which under the present conditions was the optimum induction, it was for a 10 A arc current about 30% lower than without magnetic field and was at the same induction and 15 A current intensity as large as that at 0 gauss. The amplification of the $I_L - I_U$ ratio under simultaneous improvement of its relative standard deviation and the favorable behavior of the interference level under optimum conditions caused a significant reduction of the detection limits. A good homogeneity of the longitudinal magnetic field was not necessary for obtaining the given results. (tr-auth)

#### Chemical and Spectral Procedures

*Refer also to abstracts 16485, 16539, 16728, and 16916.*

**16409** (AEC-tr-7141) DETERMINATION OF FREE ACID IN PLUTONIUM, URANIUM AND THORIUM SOLUTIONS. Schmieder, Helmut; Kuhn, Erwin. Translated from Talanta; 16: 691-700(1969). 19p. Dep. CFSTI.

An abstract of this paper, prepared from the original language, appeared as NSA 23: 28709.

**16410** (AERE-R-5914) A METHOD OF OVERCOMING MATRIX EFFECTS IN THE ANALYSIS OF COPPER ORES BY RADIOISOTOPE X-RAY FLUORESCENCE USING THE RATIO OF CHARACTERISTIC TO SCATTERED RADIATION. Dziunikowski, B.; Clayton, C. G. (United Kingdom Atomic Energy Authority, Wantage (England). Research Group). Dec 1969. 19p. Dep. CFSTI (U. S. Sales Only). UK 3s. 6d.

A method is described for overcoming matrix effects due to variations in the concentration of iron and in general lithology on the measurement of the copper concentration of copper ores when no other major interfering elements are present. It is based on compensating for the effects of variations in mean atomic number of the base matrix on the measurement of Cu K and Fe K x-ray intensities, using differential filter techniques, thereby reducing the problem to one of single element interference, capable of being resolved by means of a nomogram. (auth) (UK)

**16411** (APDA-238) EVALUATION OF THE PROPOSED ASTM METHOD FOR MEASURING OXYGEN IN SODIUM UTILIZING A ROUND ROBIN PROGRAM. Meacham, S. A.; Hill, E. F. (Atomic Power Development Associates, Inc., Detroit, Mich.). Jan 1970. Contract AT(11-1)-865. 82p. Dep. CFSTI.

Work Performed under United States–Euratom Fast Reactor Exchange Program.

A round robin program involving five laboratories selected by the sponsor for their experience with the mercury amalgamation procedure was conducted for measuring oxygen in sodium. The objective of the program was to establish the precision of a revised mercury amalgamation analytical procedure as prepared by a cognizant ASTM subcommittee. A statistical evaluation of the round robin results using the proposed procedure indicates a relative standard deviation ($s/\bar{x}$) of ± 30% at the 7 ppM oxygen level and ± 15% at the 30 ppM oxygen level. Results of the round robin program also demonstrated that the pinched tube method of preparing sodium samples, developed by APDA, resulted in samples that were homogeneous within ± 25% at a 95% confidence level. Graphical analyses of the data indicate that the procedure and its execution in some of the participating laboratories can and should be improved. The reproducibility of the analytical blank was investigated and results indicate a need for further investigation into the source of its variability. Additional work needed to improve the mercury amalgamation includes analytical blank and mercury purity studies. A revised amalgamation procedure, based on the

experience gained from this round robin, is presented for consideration. (auth)

**16412** (DEP-69-2) FIELD METHOD FOR THE DETERMINATION OF LEAD IN GLASS USED FOR SHIELDING TELEVISION RECEIVER COMPONENTS. Levine, Harry; Ruggera, Paul S. (Bureau of Radiological Health, Rockville, Md. Div. of Electronic Products). Dec 1969. 12p.

A method is described for a rapid field test for determining the lead content in glass used for shielding television receiver components as well as glass covering diagnostic x-ray fluoroscopic screens. Information can thus be gathered to determine with relative certainty the ability of the glass to absorb x rays. Measurements made to show the relative comparison between the lead content of glass in the envelope and the resultant exposure rate are described and results reported. The analytical method is based on the action of a mixture of HF and NaI on lead contained in glass and ceramics. (M.C.G.)

**16413** (USGS-474-67) CHEMICAL AND RADIOCHEMICAL ANALYSES OF WATER FROM STREAMS, RESERVOIRS, WELLS, AND SPRINGS IN THE RULISON PROJECT AREA, GARFIELD AND MESA COUNTIES, COLORADO. Larson, J. D.; Beetem, W. A. (Geological Survey, Denver, Colo.). Jan 1970. Contract AT(29-2)-474. 16p. (PNE-R-15). Dep. CFSTI.

A program for collecting water samples from surface waters in the Rulison project area and vicinity is being conducted by the U. S. Geological Survey in cooperation with the U. S. Atomic Energy Commission, primarily to provide background data on the quantity and quality of ground and surface waters. A description of the sampling locations and chemical analyses available to date are summarized. Data on chemical analyses and sampling locations are tabulated. Following the nuclear event, selected wells, springs, and cisterns were physically examined to provide background information for evaluation of possible damage complaints. The data obtained are tabulated. (P.C.H.)

**16414** ARSENATO-IODOMETRIC METHOD FOR DETERMINATION OF STRONTIUM IN THE PRESENCE OF IRON, ALUMINUM, AND TITANIUM. Shakhtakhtinskii, G. B.; Aslanov, G. A.; Dzhafarov, G. A. (Inst. of Inorganic and Physical Chemistry, Baku). Azerb. Khim. Zh.; No. 3, 78-81(1969). (In Russian).

A method is proposed for the arsenato-iodometric determination of Sr in the presence of Al, Fe, and Ti. The method gives results that are sufficiently accurate in 35 to 40 min. (tr-auth)

**16415** SPECTROPHOTOMETRIC INVESTIGATION OF THE REACTION OF LANTHANUM AND CERIUM WITH SULFARSAZEN. Bashirov, E. A. (Azerbaidzhan State Univ., USSR). Azerb. Khim. Zh.; No. 3, 97-100(1969). (In Russian).

The formation of lanthanum and cerium complexes with sulfarsazen was studied and optimum conditions for coupled formation, their composition, and their properties were studied. It was found that this reaction could be used in the determination of both $La^{+}$ and $Ce^{3+}$ and La in the presence of Ce. This method was used in the analysis of argillaceous rocks. (M.C.G.)

**16416** X-RAY FLUORESCENCE DETERMINATION OF LOW CONCENTRATIONS OF TANTALUM IN PULVERIZED SAMPLES. Donets, Yu. T.; Slutskin, M. A. (All-Union Scientific-Research and Design Inst. of Mineral Processing, Leningrad). Zh. Anal. Khim.; 25: 192-4(Jan 1970). (In Russian).

The intensity of characteristic radiation of the AuL$_\beta$-line (the material of the x-ray tube target) incoherently scattered by the sample is in fact independent of the matrix crystal structure and can be used, when determining low concentrations of tantalum, as an internal standard. The sensitivity of analysis is 0.005% of $Ta_2O_5$. The accuracy of the method is 10 to 15%. The time required for the determination is 2 to 3 minutes. (auth)

**16417** POSSIBLE USES OF RADIOACTIVE KRYPTONATES OF SILVER IN CHEMICAL ANALYSIS. Toelgyessy, J.; Jesenak, V.; Koval, E. (Technische Hochschule, Bratislava). J. Radioanal. Chem.; 4: 13-19(Jan 1970). (In German).

The radioactive kryptonate of silver has been prepared by ion bombardment. Some possibilities of its uses in analytical chemistry are reported. The influence of different solutions on Ag($^{85}$Kr) has been studied with respect to the use of kryptonate in the role of an end-point indicator in volumetric determination (determination of $Ba^{2+}$ with the titrant $K_2Cr_2O_7$) and in the technique of calibration curves [determination of HCl, $Cr_2O_7^{2-}$, and $V(OH)_4^{+}$]. (auth)

**16418** STUDIES ON TRACE CONSTITUENTS OF THERMAL SPRING WATER IN IIZAKA SPA. APPLICATION OF ATOMIC ABSORPTION SPECTROMETRY FOR THE DETERMINATION OF Sr AND Cu IN THERMAL SPRING WATER. Miyanaga, Tokuichi (Fukushima Prefectural Inst. of Health, Japan). Onsen Kogakkaishi; 7: No. 1, 1-5(Nov 1969). (In Japanese).

Emission spectroanalysis of evaporated residue from the Iizaka hot spring was carried out and trace elements such as Sr and Cu were found. Contents of Sr and Cu were determined by atomic-absorption spectrometry. For the determination of Sr; an addition of 2000 ppM La was found to be sufficient to suppress interference. Cu was also determined by atomic absorption spectrometry after extraction into methyl isobutyl ketone (MIBK) with 0.1% sodium diethyldithiocarbamate. (NSA of Japan)

**16419** METHOD FOR REMOVING HYDROGEN FROM LIQUID METALS. Hill, Eugene Farrell. British Patent 1,178,281. 21 Jan 1970. Priority date 23 May 1966, United States.

Hydrogen is separated from a body or stream of liquid metal by allowing the H to diffuse from the metals at a temperature of 260 to 760°C through a H-permeable bimetallic barrier composed of a layer of Fe, Ni, Ta, Nb, or their alloys in contact with the liquid metal and a layer of Pd, Pt, or their alloys in contact with an oxidizing atmosphere to convert the H to $H_2O$. The process is adaptable to the removal and determination of hydrogen in liquid-metal coolants for reactors. (B.L.M.)

**16420** COULOMETRIC DETERMINATION OF MANGANESE(II), CERIUM(III), AND VANADIUM(IV). Kostromin, A. I.; Akhmetov, A. A.; Orlova, L. N. (Kazan State Univ.). Zh. Anal. Khim.; 25: 195-6(Jan 1970). (In Russian).

The coulometric titration of small amounts of manganese(II), cerium(III), and vanadium(IV) with electrogenerated dichromate has been carried out in 12M $H_3PO_4$. The end point of titration has been established by various methods. The possibility of determining manganese in brass and bronze is discussed. (auth)

**16421** QUANTITATIVE AND ISOTOPIC DETERMINATION OF GASEOUS COMPOUNDS PRODUCED DURING DENITRIFICATION BY MASS SPECTROMETRY. Guiraud, G.; Berlier, Y. (CEA, Cadarache, France). Chim. Anal. (Paris); 52: 53-6 (Jan 1970). (In French).

Direct measurement of gaseous losses by denitrification of soil samples is possible only in confined atmospheres. An incubator was designed enabling spectrometric analyses to be performed. The method was developed to obtain accurate measurements. The isotopic and quantitative determination of gaseous $N_2$ and $N_2O$ is thus made possible and their variation made measurable. (France)

**16422** CONTEMPORARY ANALYTICAL METHODS OF DETERMINATION AND THE SEPARATIONS OF SCANDIUM. Eremin, Yu. G.; Katochkina, V. S. Zavod. Lab.; 35: 1425-31 (1969). (In Russian).

A review is given on the analytical chemistry of Sc for the period 1960 to 1968. Some of the methods discussed include precipitation and gravimetric, volumetric, and photometric, methods for determination and extraction and chromatographic separation. (125 references). (tr-auth)

**16423** DETERMINATION OF RARE EARTH IMPURITIES IN GADOLINIUM OXIDE BY LUMINESCENCE METHOD. Poluektov, N. S.; Gava, S. A. (Inst. of General and Inorganic Chemistry, Odessa). Zavod. Lab.; 35: 1458-61(1969). (In Russian).

The results showed the possibility of the determination of trace amounts of Nd, Sm, Eu, Tb, Dy, Ho, Er, Tm, and Yb in pure gadolinium oxide by the luminescence method using crystal phosphors based on gadolinium orthovanadate and excitation by uv light from a mercury lamp. (tr-auth)

**16424** SQUARE WAVE POLAROGRAPHIC DETERMINATION OF IRON IN HIGHLY RADIOACTIVE SOLUTIONS BY REMOTELY OPERATED METHOD. Emura, Satoru; Sugikawa, Susumu (Japan Atomic Energy Research Inst., Tokai). Jap. Anal.; 19: 212-16(Feb 1970). (In Japanese).

A remotely operating square-wave polarographic method was established for the determination of iron in dissolver and highly radioactive waste solutions (1AW) from irradiated fuel reprocessing. By adding triethanolamine as a complexing agent, the iron wave caused a shift in E 1/2 to more negative potentials. Also, the interference from uranium was eliminated by addition of ammonium carbonate. The recommended procedure is as follows. In a polarographic cell are mixed 500 µl of sample solution and 5.0 ml of supporting electrolyte containing 13.2% triethanolamine, 0.22M ammonium carbonate and 1.1M ammonium hydroxide. After deaeration with nitrogen for 15 minutes, the polarogram is recorded from 0 to −0.5 V vs mercury anode. Iron content is determined by referring to a calibration curve. The determinable limit of concentration of iron is 10 ppM. The relative standard deviation was less than 5.0%, for iron in feed solution to 1A col-

umn (1AF) and highly radioactive waste solution of reprocessing plant. (auth)

**16425** SPECTROPHOTOMETRIC DETERMINATION OF MOLYBDENUM IN TUNGSTEN-BEARING STEELS BY THIOCYANATE-SOLVENT EXTRACTION. Uehara, Fumio (Government Chemical Industrial Research Inst., Tokyo); Furuno, Akiyoshi. Jap. Anal.; 19: 183-7(Feb 1970). (In Japanese).

A selective spectrophotometric method was proposed for determination of molybdenum in tungsten-bearing steels, and the recommended procedure is as follows. After adding tartaric acid and sodium hydroxide to a sample solution, it is made to contain 10% sulfuric acid. To it are added 5 ml of 5% sodium thiocyanate and 5 ml of 35% stannous chloride solution, and the colored molybdenum complex is extracted by shaking for 5 min with 25 ml of butyl acetate. The absorbance is measured at a wavelength of about 470 mμ (filter). Tungsten(VI) in amounts one hundred times as much as molybdenum does not interfere. Cr(VI), V(V), Ni(II), Co(II), and Cu(II) do not interfere. Beer's law is obeyed over the range 0.03 to 3.2 μg Mo/ml, and the apparent molar extinction coefficient is 18,700. The proposed method was applied to the determination of molybdenum in chromium steels and high speed steels. The results agreed with standard values, the relative error being less than 3%. (auth)

**16426** SIMULTANEOUS DETERMINATION OF TUNGSTEN AND MOLYBDENUM BY HIGH-FREQUENCY PLASMA TORCH SPECTROMETRY. Suzuki, Mitsuyasu (Tohoku Univ., Sendai). Jap. Anal.; 19: 207-12(Feb 1970). (In Japanese).

In order to determine simultaneously tungsten and molybdenum by high-frequency plasma torch spectrometry, experimental conditions were examined. The most suitable conditions were: magnetron anode current 140 mA, argon gas as the tangential gas 6 l/min, argon gas as the carrier 2.5 l/min, and analytical lines MoI 3864.11 Å and WI 4008.75 Å. Iron, nickel, manganese, chromium etc. did not influence the intensity of the analytical lines, but the intensity was reduced in the sample solution containing sodium. Tungsten and molybdenum in Fe–Mo alloys, Fe–W alloys, high-speed steels, and tool steels could be determined rapidly with high precision. (auth)

**16427** DETERMINATION OF TRACES OF TELLURIUM IN ROCKS BY ATOMIC ABSORPTION SPECTROSCOPY AFTER VOLATILIZATION WITH SYNTHETIC PYRITE. Davis, C. E. S.; Ewens, W. E.; Fletcher, A. B. (Commonwealth Scientific and Industrial Research Organization, Wembley, Australia). Australas. Inst. Mining Met. Proc.; No. 232, 67-72(Dec 1969).

Tellurium was determined at concentrations down to 0.01 ppM, with geochemical accuracy. Tellurium was volatilized from the rock at 800°C in the presence of sulphur from decomposing pyrite, condensed, dissolved, and finally determined by atomic absorption in a long tube burner. The distribution of Te was shown near some gold lodes at Kalgoorlie. Lastly, a method of synthesizing Te-free pyrite from sulphur and ferrous sulphate is described. (Australia)

**16428** DETERMINATION OF METALS IN LIFE TISSUE BY ATOMIC ABSORPTION METHOD. 1. METHOD FOR DETERMINATION OF CALCIUM AND STRONTIUM. Nozaki, Yukinori; Yagi, Hiroshi (Nagasaki Univ.). Nagasaki Daigaku Suisangakubu Kenkyu Hokoku; No. 27, 65-71(Aug 1969). (In Japanese).

The determination of Ca and Sr in living tissues by atomic absorption was investigated. Studies were made on the interference of ions coexisting in sample solutions and on the elimination of such interference using seawater rather than solutions of ashes of living tissues. Interferences were obviated by adding a large amount of $LaCl_3$. (NSA of Japan)

**16429** SPECTROPOLARIMETRIC DETERMINATIONS OF THE LANTHANIDE METALS WITH D-(-)-1,2-PROPYLENEDIAMINETETRAACETIC ACID. Caldwell, D. L.; Reinbold, P. E.; Pearson, K. H. (Texas A and M Univ., College Station). Anal. Chem.; 42: 416-18(Mar 1970).

Spectropolarimetric titrations of rare earths with D–(–)–1, 2–propylenediaminetetraacetic acid were carried out. Results for La, Sm, Pr, Eu, Yb, Nd, Gd, and Th are given. An error 0.37% was found compared with EDTA titrations. (M.C.G.)

**16430** ANALYTICAL APPLICATIONS OF X-RAY EXCITED OPTICAL FLUORESCENCE SPECTRA. DIRECT DETERMINATION OF FRACTIONAL PARTS PER MILLION AMOUNTS OF RARE EARTHS IN THORIUM. Saranathan, T. R.; Fassel, V. A.; DeKalb, E. L. (Ames Lab., Iowa). Anal. Chem.; 42: 325-9(Mar 1970).

An x-ray excited optical fluorescence method for the direct quantitative determination of fractional part per million amounts of Pr, Sm, Eu, Gd, and Dy in nuclear grade thorium is described. Prior chemical separation of the rare earths is not required. The thorium oxide host is prepared by evaporating thorium nitrate solutions to dryness and igniting the residue at 1000°C for three hours. Selected erbium lines are employed as internal standards to correct for the depressing effect caused by other impurities present in the sample. The concentration range for which analytical curves were established are: 0.08 to 4 ppM for Pr, 0.12 to 6 ppM for Sm, 0.04 to 2 ppM for Eu, 0.1 to 1 ppM for Gd, and 0.2 to 10 ppM for Dy. (auth)

**16431** THE MEASUREMENT OF RELATIVE ISOTOPE ABUNDANCE RATIOS BY NUCLEAR MAGNETIC RESONANCE TECHNIQUES. Fujiwara, Shizuo (Tokyo Univ.). Chem. Instrum.; 2: No. 1, 103-9(Jul 1969).

NMR techniques are shown to constitute an alternative to the established mass spectrometric method for isotope abundance measurements. Illustrative examples are given for $^{199}Hg$, $^{10}B$, $^{11}B$, $^{13}C$, and $^{29}Si$. (auth)

**16432** PHOTOMETRIC DETERMINATION OF SMALL AMOUNT OF TELLURIUM IN IRON AND STEEL WITH BISMUTHIOL. II. Maekawa, Shizuya; Kato, Kiyotoshi (Japan Steel Works Ltd., Muroran). Jap. Anal.; 19: 10-16(Jan 1970). (In Japanese).

A photometric determination of 0.0001 ~ 0.01% of tellurium in iron and steel with Bismuthiol II was investigated. The tellurium–Bismuthiol II complex was extracted with chloroform, benzene, and carbon tetrachloride from a 0.8 ~ 6N hydrochloric acid, sulfuric acid, or perchloric acid solution. This complex showed an absorption maximum at 335 mμ, and Beer's law was obeyed up to 50 μg of tellurium when 1 ml of Bismuthiol II solution (0.1%) was used. The established method was as follows. A half gram of sample was decomposed in 30 ml of sulfuric acid (1 + 5) and was filtered through a filter paper. The residue was dissolved in hydrochloric acid and hydrogen peroxide and boiled for 5 minutes. Tellurium was separated by precipitation as metallic tellurium together with arsenic added as a carrier by reducing with stannous chloride. It was dissolved in nitric acid and perchloric acid and evaporated to vigorous fumes of perchloric acid. After cooling, 5 ml of hydrochloric acid (6N) and 1.0 ml of Bismuthiol II solution were added, and it was shaken for 30 sec with 10.0 ml of carbon tetrachloride. The organic layer was washed successively with the washing solution (dissolving 10 g of potassium phosphate, 17g of sodium borate, and 10 g of EDTA in water to make up to 1 liter) and the absorbance was measured at 335 mμ against carbon tetrachloride. This method was very sensitive and simple, and the time required for an analysis was about 50 minutes. (auth)

**16433** X-RAY ENERGY SPECTRA OF SOME LIGHT ELEMENTS. Soriano, V. B.; Guzman, D. L.; Navarro, Q. O. (Philippine Atomic Research Center, Quezon City). Philippines Nucl. J.; 2: 107-15(1969).

A method is described using $^{35}S$ ($\beta$ energy 168 keV) and the direct transmission geometry in obtaining the x-ray spectra of the light elements Fe, Cu, Ag, and Au. Examples of the spectra obtained are given. (auth)

**16434** GRAVIMETRIC DETERMINATION OF NIOBIUM AND TANTALUM IN HEAT RESISTANT ALLOYS WITH TETRAPHENYLARSONIUM CHLORIDE. Kajiyama, Rokuro (Nippon Yakin Kogyo Co., Ltd., Kawasaki, Japan). Jap. Anal.; 19: 26-9(Jan 1970). (In Japanese).

Tantalum and niobium in heat resistant alloys were precipitated quantitatively by tetraphenylarsonium chloride (TPAC) from, respectively, >1M and >8M hydrofluoric acid solution, and were readily separated from tungsten, molybdenum, titanium, and zirconium. A sample was taken in a polyethylene beaker, and decomposed by heating on a boiling water bath with 30 ml of hydrofluoric acid and 40 ml of aqua regia. The solution was then made up to 130 ml with 30 ml of hydrofluoric acid and water. Twenty milliliters of TPAC solution (0.025M) was added, and the mixture was allowed to stand for 30 min in the water bath drawn from fire. The aged precipitate was filtered with a bit of paper pulp through a filter paper and washed with TPAC washing solution (10 ml of TPAC solution and 1 l of 1M hydrofluoric acid). It was then transferred to a high purity alumina crucible, ignited at 900°C for an hour, and weighed as combined pentoxides. If necessary, the oxides were fused to dissolve for respective determinations of Nb and Ta by spectrophotometry. The mutual separation of niobium and tantalum was not possible by this procedure. (auth)

**16435** SPECTROPHOTOMETRIC DETERMINATION OF MOLYBDENUM(VI) BY EXTRACTION OF MOLYBDENUM–PYROCATECHOL VIOLET COMPLEX WITH QUATERNARY AMMONIUM CHLORIDE. Kohara, Hitoshi; Ishibashi, Nobuhiko; Abe, Kyomi (Kyushu Univ., Fukuoka). Jap. Anal.; 19: 48-54 (Jan 1970). (In Japanese).

The extraction–spectrophotometric determination of molybde-

num(VI) has been investigated by the extraction of molybdenum complex of Pyrocatechol Violet with quaternary ammonium salt. Molybdenum complex of Pyrocatechol Violet is extracted into various organic solvents in the presence of dialkylmethylbenzylammonium chloride, but the composition of the complex extracted into the organic solvent depends on ligand concentration and pH of aqueous phase. The complex extracted into chloroform from 0.25 ~ 0.6 M hydrogen chloride solution has an absorption maximum at 560 mμ, the molar ratio of molybdenum to Pyrocatechol Violet being 1 to 2. Under optimum conditions, Beer's law is obeyed at least up to $10 \times 10^{-6}$ M molybdenum in chloroform. Tin(IV) and tungsten(VI) interfere with the determination. Zirconium(IV) forms a complex with Pyrocatechol Violet but is not extracted. The extraction with quaternary ammonium salt liberates the hydrogen ion associated with the carbonyl group of Pyrocatechol Violet in an acidic medium. (auth)

**16436** DETERMINATION OF THE OXYGEN-TO-URANIUM R RATIO IN HYPOSTOICHIOMETRIC URANIUM DIOXIDE. Tolk, A.; Lingerak, W. A.; Boerger, D. (Reactor Centrum Nederland, Petten). Anal. Chim. Acta; 49: 437-42(Mar 1970).

For the determination of the oxygen-to-uranium ratio in hypostoichiometric uranium dioxide, a method was developed in which the sample is dissolved in phosphoric acid. During dissolution, all uranium present is converted to uranium(IV) while an amount of hydrogen equivalent to the degree of hypostoichiometry is released. The O/U ratio is determined from the amount of released hydrogen. Satisfactory results, in accordance with those obtained gravimetrically on 1-g samples, can be obtained on 30 to 140 mg samples. (auth)

**16437** PRECISE DETERMINATION OF URANIUM IN IMPURE URANYL NITRATE AND URANIUM OXIDES. Walker, C. R.; Vita, O. A. (Goodyear Atomic Corp., Piketon, Ohio). Anal. Chim. Acta; 49: 391-400(Mar 1970).

A method is presented for the direct determination of uranium in uranium compounds containing up to several percent impurities with a precision of 0.04% at the 95% confidence interval. The method is simple and is a significant improvement over existing methods for analysis of this type of material. A sample containing about 2.5 g of uranium is dissolved in strong phosphoric acid and uranium(VI) is reduced with iron(II). After selective oxidation of the excess of iron(II) with nitrate in the presence of molybdate catalyst, a small excess of potassium dichromate is added to oxidize uranium(IV) to uranium(VI). The excess of chromium(VI) is determined colorimetrically with diphenylcarbazide. The method requires some prior knowledge of the uranium content of the sample. It can be applied even in the presence of percent levels of impurities such as iron, nickel, and chromium. Copper, however, at concentrations of more than 1% of the uranium causes a low bias. (auth)

## *Isotopic Procedures*

*Refer also to abstract 16687.*

**16438** SUBSTOICHIOMETRIC ISOTOPE DILUTION ANALYSIS OF COPPER TRACES IN ZINC BY ADSORPTIVE SAMPLING. Miller, J. (Inst. of Isotopes, Budapest). J. Radioanal. Chem.; 4: 35-44(Jan 1970).

The spontaneous deposition of $Cu^{2+}$ from aqueous solutions on a hydrogen-saturated platinum surface as a possibility for the substoichiometric sampling of copper is discussed. A sensitive isotope dilution method has been developed for the determination of traces of copper in high purity zinc making use of the spontaneous deposition of microquantities of $Cu^{2+}$ from aqueous solutions of zinc salts on a cathodically polarized platinum surface. If the same platinum surface is used in each run, the saturation values of the deposited copper are practically independent of the concentrations and contents of copper and zinc in the solution. The copper traces were labeled with the product of the $^{64}Zn(n,p)^{64}Cu$ nuclear reaction. A copper content of 0.18 ± 0.03 ppM in zinc was determined by this method. (auth)

**16439** MICROANALYSIS BY SUCCESSIVE ISOTOPIC DILUTION. A NEW ASSAY FOR RACEMIC CONTENT. Kemp, D. S.; Wang, S. W.; Busby III, G.; Hugel, G. (Massachusetts Inst. of Tech., Cambridge). J. Amer. Chem. Soc.; 92: 1043-55(25 Feb 1970).

An isotopic dilution assay for racemate with sensitivity in the important 1 to 0.001% concentration range is outlined, and results are reported for its application to syntheses of the Anderson peptide, ethyl benzyloxycarbonylglycylphenylalanylglycinate, and the Young peptide, ethyl benzoylleucylglycinate, by isoxazolium salt couplings and by the acyl azide procedure. The Anderson test is used to explore the effect of solvent on racemate formation during p-nitrophenyl ester couplings, and the triethylamine-catalyzed racemization rate of the Anderson peptide in ethanol is reported. The Young test appears to have roughly ten times the sensitivity of the Anderson test. Under optimal conditions, acylazide and 3-acyloxy-2-hydroxy-N-ethylbenzamide couplings generate similar levels of racemate, 0.015% by the Anderson and 0.25% by the Young assay. (auth)

## *Radiometric Procedures*

*Refer also to abstracts 16835, 16844, 16851, 16852, and 16924.*

**16440** (EUR-4329) ALPHA-SPECTROMETRIC ISOTOPE ABUNDANCE ANALYSIS OF URANIUM USING SEMICONDUCTOR DETECTORS. Litzow, W.; Merz, E. (Kernforschungsanlage, Juelich (West Germany)). 1969. 24p. (In German). (THTR-90). Dep. CFSTI (U. S. Sales Only).

Nuclear technology very often requires precise knowledge of the composition and enrichment of uranium isotopes, in particular the fissile isotopes $^{235}U$ and $^{233}U$. Because of its alpha-instability, spectrometry using semiconductor detectors can be successfully used for quantitative determination. The accuracy of these abundance analyses depends mainly on the particle detection probability of the method, and also on adequate energy resolution because of the predominantly statistical sources of error. A particular advantage of this spectrometric method, and one that considerably simplifies evaluation, is that the half-widths of the individual alpha lines over the whole of the energy range from 4 to 5.5 MeV can be considered constant. The measuring preparations are made by electrodeposition of the uranium from an organic electrolytic solution on nickel cathodes. This method is known as "molecular plating." To plot the alpha spectra, a semiconductor detector with a counting surface of 25 $mm^2$ and an energy resolution of 17 keV half-width was employed. With the overall spectrometric device a maximum energy resolution of 19 keV was attained. The optimum conditions for the abundance analysis of the uranium stipulate an energy resolution of 25 keV and a particle detection probability of 0.5%. After a measuring time of 72 hr the enrichment factor of a $^{235}U$-enriched uranium mixture was ascertained to an accuracy of ±10%. Increased accuracy is possible with longer measuring times and programmed calculation. (auth)

**16441** (RPI-3836-3) URANIUM GEOCHEMISTRY IN CARBONATES USING THE FISSION TRACK METHOD. Technical Progress Report. Friedman, Gerald M.; Miller, Donald S. (Rensselaer Polytechnic Inst., Troy, N. Y.). Jan 1970. Contract AT(30-1)-3836. 3p. Dep. CFSTI.

Fission-track analysis was used to map uranium distributions in sections of recent skeletal carbonates at the ppB to ppM level. Considerable intraskeletal heterogeneities were found in corals and mollusks. Cemented carbonates were also analyzed for uranium distribution. (M.C.G.)

**16442** A NEW RADIOMETRIC TITRATION METHOD BASED ON SEPARATION BY MEANS OF ION EXCHANGE. III. THE DETERMINATION OF ZINC IN THE PRESENCE OF OTHER METALS. Heijink, A.; Polak, H. L. (Univ. of Amsterdam). J. Radioanal. Chem.; 4: 63-73(Jan 1970).

A mathematical expression is derived for the radiocomplexometric determination of a mixture of two metals with one ligand, using an anion exchanger in the solution as a phase separating system. An expression is also given for the complexometric titration of a metal, when formation of acidic or basic complexes is taken into account. In the experimental part titration procedures are proposed for determinations of copper and iron, using $^{65}Zn$ as indicator. The formation of the acidic complex, ZnHY, does affect the radiometric titration curve of zinc with EDTA. (auth)

**16443** DETERMINATION OF $^{243}Am$ IN $^{244}Cm$ BY GAMMA SPECTROSCOPY. Wakat, M. A.; Dukes, E. K. (E. I. du Pont de Nemours and Co., Aiken, S. C.). J. Radioanal. Chem.; 4: 109-14(Jan 1970).

Gamma spectroscopy with a high resolution Ge(Li) detector was used to determine $^{243}Am$ by its 74.7-keV gamma transition in solutions containing much higher specific activities of other actinides and fission products. As little as 100 ppM of $^{243}Am$ relative to $^{244}Cm$ can be determined. A relative standard deviation of 1.4% was obtained for routine samples. The method is well suited for analytical control of curium process steps because of its simplicity, speed, and reliability. (auth)

**16444** ASSAY OF $^{129}I$ BY LIQUID SCINTILLATION COUNTING: USE OF $^{14}C$ AS AN INTERNAL STANDARD. Ross, H. H. (Oak Ridge National Lab., Tenn.). Radiochem. Radioanal. Lett.; 3: 57-61(11 Feb 1970).

A common liquid scintillation standard, toluene-$^{14}C$, can also

be used as a standard for the measurement of $^{129}I$ in both organic and aqueous samples. (auth)

**16445** DETERMINATION OF ISOTOPIC RATIO OF URANIUM BY NEUTRON IRRADIATION. Ohyoshi, E.; Ohyoshi, A.; Shinagawa, M. (Osaka Univ.). Radiochem. Radioanal. Lett.; 3: 7-11(11 Feb 1970).

An attempt to estimate the isotopic ratio of uranium was made using the relationship between the amount of one kind of fission nuclide and that of $^{239}Np$. For the separation of nuclides produced by irradiation of uranium, focusing chromatography was applied. A plot of the activity ratio of the fission nuclide, $^{99}Mo$, $^{132}Te$, or $^{143}Ce$ to $^{239}Np$ against the isotopic ratio, $^{235}U/^{238}U$ nearly fell on a straight line when the value of $^{235}U/^{238}U$ was less than about 0.25. Within such a region, this method seems to be applicable for the conventional estimation of the isotopic ratio of uranium. (auth)

**16446** RADIOCHEMICAL DETERMINATION OF SEVERAL NUCLIDES FOR $^{235}U$ FISSION. Ohyoshi, E.; Ohyoshi, A.; Shinagawa, M. (Osaka Univ.). Radiochem. Radioanal. Lett.; 3: 1-5(11 Feb 1970).

The separation technique, focusing chromatography, was applied to determine the fission yields of several nuclides for $^{235}U$ /$n_{th}$ f/ using the comparison method. The results were compared with data in the literature. (auth)

**16447** A STABLE LIQUIFLUOR SOLUTION FOR COUNTING $^{35}S$ IN PROTEIN-FREE SOLUTION PREPARED FROM PLASMA SAMPLES. Varrone, E.; Albert, S. N. (Washington Hospital Center, Washington, D. C.). J. Nucl. Med.; 10: 263-4 (June 1969).

An efficient and stable liquifluor solution was developed for counting weak-beta-emitting nuclides at room temperature in acid aqueous solutions containing a high concentration of crystalloids. (auth)

**16448** RESOLVING POWER OF GAMMA-RAY COINCIDENCE SPECTROMETRY USING LITHIUM DRIFTED GERMANIUM DETECTORS AND ITS APPLICATION TO MULTIPLE RADIOISOTOPE ANALYSIS. Pagden, I. M. H.; Sutherland, J. C. (Bedford Inst., Dartmouth, Nova Scotia). Anal. Chem.; 42: 383-7(Mar 1970).

Computer studies were made of the cascade gamma rays of (n,γ) activation products to determine which pairs of gamma ray coincidences could be unambiguously identified in a comprehensive radioisotope mixture. The resolution of the coincidence photopeaks was investigated as a function of detection resolution and tables condensed from the computer output are presented. The currently achievable resolving powers of Ge(Li) detectors are such that most coincidence photopeaks can be unambiguously identified and if used for radiochemical analysis, would be, in the chemical sense, interference free. This is contrasted with simple detector spectra of radiochemical mixtures where the majority of photopeaks exhibit varying degrees of interference. A brief discussion of possible experimental effects resulting from this approach and their bearing on some of the conclusions drawn is included. (auth)

**16449** HOMOGENIZED FISSION TRACK DETERMINATION OF URANIUM IN WHOLE ROCK GEOLOGIC SAMPLES. Fisher, David E. (Univ. of Miami, Fla.). Anal. Chem.; 42: 414-16(Mar 1970).

The method of fission track analysis was modified to make it suitable for whole-rock U determination. The results indicate, in a qualitative manner, the degree of heterogeneity of the U distribution within the total rock. (M.C.G.)

**16450** DETERMINATION OF PLUTONIUM IN BIOLOGICAL MATERIALS BY EXTRACTION AND LIQUID SCINTILLATION COUNTING. Keough, R. F.; Powers, G. J. (Battelle-Northwest, Richland, Wash.). Anal. Chem.; 42: 419-21(Mar 1970).

The method described utilizes the direct extraction of plutonium from the acidic solution of sample ash into a toluene solution of bis(2-ethylhexyl) phosphate and scintillators. Carrying out the extraction in the counting vial increases precision and speed, while reducing the opportunities for cross-contamination. Liquid scintillation counting is done with both phases present in the vial. (M.C.G)

**16451** DETERMINATION OF CARRIER-FREE PROMETHIUM BY ION-FOCUSING ELECTROPHORESIS. Gee, H. Y.; Nathans, M. W. (LFE Corp., Richmond, Calif.). Anal. Chem.; 42: 425(Mar 1970).

Ion-focusing electrophoresis was investigated as a method for determination of fission product promethium. (M.C.G.)

**16452** RADIOCHEMICAL DETERMINATION OF RADIUM-B/C IN RAIN WATER. DISCUSSION OF THE POSSIBLE ROLE OF THE $^{222}Rn$ DAUGHTER NUCLIDES IN THUNDERSTORM ELECTRIFICATION. Michaelis, Martin L.; Mainz, M. A. Chem. Ztg.; 93: 883-95(20 Nov 1969). (In German).

A method was developed for determination of Radium B and Radium C in rainwater. With the help of the basic assumption that the Radium A incorporation represents a significant part of the primary activity of cloud elements, the results are explained. These methods were used to determine the lifetime of cloud elements from their formation to their release in precipitation. The results are discussed on the basis of large and small weather conditions. This led to speculation on the roll of natural radioactivity in the identification of cumulus clouds. The alpha particles of Radium A and C can lead to the previously missing quantitative explanation for electrification in common thunderstorms. (tr-auth)

**16453** IONIZATION SPECTROSCOPY OF SURFACES. Gerlach, Robert L.; Houston, J. E.; Park, Robert L. (Sandia Labs., Albuquerque, N. Mex.). Appl. Phys. Lett.; 16: 179-81(15 Feb 1970).

A technique is described for the analysis of surface composition on the basis of characteristic loss features associated with electron-impact ionization of inner atomic levels. The method involves separating the characteristic loss spectrum from the total secondary emission spectrum by superimposing a small oscillation on the primary beam energy and detecting only those features which fluctuate at the same frequency. Ionization spectroscopy is shown to have a number of inherent advantages over conventional Auger spectroscopy. (auth)

## *Activation Procedures*

*Refer also to abstracts 16670 and 17278.*

**16454** NEUTRON ACTIVATION ANALYSIS IN THE MINERAL OIL INDUSTRY. II. APPLICATION EXAMPLES. Rodenbusch, Heinz (Mobil Oil AG in Deutschland, Hamburg); Prokop, Reiner. Erdoel Kohle; 22: 463-7(Aug 1969). (In German).

The applications of neutron activation in the analyses of crude oils, finished products, wear elements, engine deposits, and residues are discussed. It is shown that various elements such as V, Na, Al, Cl, and Zn can be analyzed nondestructively down to the 1 ppB range in 25 to 40 min. In lubrication studies, after irradiation of engine parts in a reactor, the activated elements were determined in the lubricating oil. Iron, Cr, Mo, and Zn are especially useful for such analyses. Alternately the oil can be analyzed directly by the neutron activation method. Borehole logging by means of small neutron sources in the oil and gas industry is also described. (BBB)

**16455** ACTIVATION ANALYSER. Fujii, Isao (to Tokyo Shibaura Electric Co. Ltd.). British Patent 1,178,611. 21 Jan 1970. Priority date 28 Jan 1966, Japan.

Activation analysis apparatus for determining the percentage by weight of an element in a given sample comprises means for activating the sample by irradiation, means for detecting the radiation from the sample resulting from the activation and for producing a first train of pulses, and means of receiving the first train of pulses and producing a second train of pulses in responses to the first one. The number of pulses in the first train occurring in unit time is a function of the intensity of radiation from the element, and the second train of pulses is so produced that a single pulse in this second train is produced in response to every $(W_s/100K \times 1/10^m)$ successive pulse of the first train where $W_s$ is the weight of the sample, K is the weight of the element to be determined, and $10^m$ is a direct digital measure of the percentage by weight of the element in the sample. A block diagram of the apparatus is included. (B.L.M.)

**16456** DETERMINATION OF THE $^{35}Cl/^{37}Cl$ RATIO IN BEPPU HOT SPRING WATER BY FAST NEUTRON ACTIVATION ANALYSIS. Oda, Toshiyuki; Kawakami, Hiroyasu (Kyushu Univ., Oita, Japan). Oita-ken Onsen Chosa Kenkyu-kai Hokoku; No. 20, 63-5(Mar 1969). (In Japanese).

The ratio of $^{35}Cl$ to $^{37}Cl$ was determined in Beppu hot spring water, in volcanic gas, and in natural NaCl. The $^{37}Cl$ was determined by measurement of the 0.12-MeV peak arising from the reaction $^{37}Cl(n,2n)^{36}Cl$. The spring water was alkalized, dried, and $Cl_2$ generated by addition of $H_2SO_4$ and absorbed by NaOH solutions. The NaOH solution was evaporated to dryness, and the resulting NaCl was neutron irradiated in tablet form. The irradiated samples were cooled for 5 min, and the radiation was measured on a 400-channel analyzer. The results of the analysis did not show a significant difference to establish whether the $Cl^-$ in the hot springs originated from volcanic gas, elution from rocks, or seawater. (TSS)

**16457** DETERMINATION OF TRACE ELEMENTS BY ACTIVATION ANALYSIS WITH CHARGED PARTICLES. Sparks, R. J.; McCallum, G. J. (Dept. of Scientific and Industrial Research, Lower Hutt, N. Z.). N. Z. J. Sci.; 12: 470-5(Sep 1969).

Nitrogen was determined in steel down to at least 0.01% by activation analysis with charged particles. Best results were obtained when a beam of deuterons was used. To obtain a characteristic spectrum of nitrogen for identification and comparison, a target of titanium nitride was prepared and mounted in an evacuated target chamber. The target was in the form of finely divided powder compressed and sintered into a pellet of about ¼ in. diameter and ⅛ in. thickness. A low operating voltage (1.2 MeV) was chosen in order to maximize the γ yield from light nuclei compared with that from heavier nuclei. The results illustrated the feasibility of rapidly determining simultaneously C, N, and O present in concentrations of the order of 100 ppM. (BBB)

**16458** NEUTRON ACTIVATION ANALYSIS OF THE 1965 TAAL VOLCANIC ASH. Santos, G. P.; Wainerdi, R. E. Bull. Volcanol.; 32: 575-8(1969).

Neutron activation analysis of ash from the 1965 eruption of Taal Volcano in the Philippines reveals an unusually high Sc content compared to standard basalt BCR-1 (2760 as against 2649). The eruption was probably characterized by the ejection of Sc-rich materials. Scandium may be used as supplementary evidence in forecasting activity of Taal. (Geophys. Abstr.)

**16459** ROUTINE DETERMINATIONS OF Al, K, Cr, AND Sn IN GEOCHEMISTRY BY NEUTRON ACTIVATION ANALYSIS. Das, H. A.; van Raaphorst, J. G.; Umans, H. J. L. M. (Reactor Centrum Nederland, Petten). J. Radioanal. Chem.; 4: 21-33 (Jan 1970).

An abstract of this paper, previously appeared as NSA 24: 138.

**16460** NEUTRON ACTIVATION ANALYSIS OF RARE EARTH IMPURITIES IN METALLIC URANIUM. Alimarin, I. P.; Miklishanskii, A. Z.; Yakovlev, Yu. V. (Inst. of Geochemistry and Analytical Chemistry, Moscow). J. Radioanal. Chem.; 4: 45-51 (Jan 1970).

A method with a sensitivity of $2 \times 10^{-7}$ to $1 \times 10^{-10}$% has been developed for determining Yb, Ho, Dy, Gd, Eu, Sm, and La impurities in metallic uranium by means of neutron activation. The method is based on a preliminary chromatographic separation of the total amount of rare earth elements from uranium by passing the solution in sulfuric acid through KU-2 cation exchange resin and eluting the traces of uranium retained by the resin with a solution of ascorbic acid. The rare earth impurities are then eluted from the resin with 4 to 5N HCl, evaporated, and irradiated for 20 hours with a neutron flux of $1.2 \times 10^{13}$ n · cm$^{-2}$ · sec$^{-1}$. Subsequently the traces of the rare earth elements are coprecipitated with $Fe(OH)_3$, dissolved in concentrated HCl, and separated from the iron and other impurities by passing the solution through Dowex 1X8 anion exchange resin in the chloride form. The individual rare earth elements are then separated from each other using KU-2 cation exchange resin and a solution of ammonium α-hydroxyisobutyrate as the eluant. (auth)

**16461** NEUTRON ACTIVATION ANALYSIS OF RARE EARTH IMPURITIES IN EUROPIUM OXIDE. Alimarin, I. P.; Miklishanskii, A. Z.; Yakovlev, Yu. V. (Inst. of Geochemistry and Analytical Chemistry, Moscow). J. Radioanal. Chem.; 4: 75-80 (Jan 1970).

A neutron activation analysis method for determining Yb, Dy, Ho, Sm, and La impurities in europium oxide with sensitivities of $10^{-6}$ to $10^{-7}$% is described. The method is based on a preliminary concentration of the rare earth elements by reducing europium(III) with zinc to europium(II), and separating the trivalent rare earth elements by extraction chromatography. After neutron irradiation, the individual radioisotopes of the rare earth elements are separated by using KU-2 cation exchange resin and ammonium α-hydroxyisobutyrate solutions as the eluant. (auth)

**16462** ACTIVATION ANALYSIS OF GALLIUM IN TUNGSTEN. Salamon, A. (Research Inst. for Technical Physics, Budapest). J. Radioanal. Chem.; 4: 81-6(Jan 1970).

An activation analytical method is described for the determination of small concentrations of Ga in tungsten. The samples are irradiated with reactor neutrons and dissolved in a hot chamber using a remote manipulator. After the adjustment of the pH, Ga is extracted in the form of its cupferron complex in chloroform solution. The organic phase is washed and, depending on the efficiency of the separation from tungsten, a Ge(Li) semiconductor detector, or a NaI(Tl) scintillation counter is used for the gamma-spectrometric evaluation. The sensitivity of the method for a sample of 2 g was found to be $10^{-9}$ g of Ga/g of W. The determination can be carried out, and is well reproducible, with an accuracy of ±30%. (auth)

**16463** CHARGED PARTICLE ACTIVATION ANALYSIS FOR CARBON, NITROGEN, AND OXYGEN IN SEMICONDUCTOR SILICON. Nozaki, T.; Yatsurugi, Y.; Akiyama, N. (Inst. of Physical and Chemical Research, Saitama, Japan). J. Radioanal. Chem.; 4: 87-98(Jan 1970).

Convenient processes are described for the charged particle activation analysis for carbon, nitrogen, and oxygen in semiconductor silicon. Suitable activation reactions and incident particle energies were selected, and the interferences examined; the activation curves for the $Si + {}^3He \rightarrow {}^{11}C$ and $Si + {}^3He \rightarrow {}^{18}F$ reactions, which may seriously interfere with $^3He$ activation analysis, were measured, and the interference caused by the fission of the matrix itself is discussed. A simple technique for the separation of $^{11}C$ present in silicon is proposed. Reliable determination of as low as several parts per billion of the three elements has thus become possible. Semiconductor silicons of various origin were analyzed for C, N and O, and the behaviour of these elements during zone-melting is reported. (auth)

**16464** NONDESTRUCTIVE DETERMINATION OF NUCLEAR FUEL BURN-UP BY MEASURING THE GAMMA RADIATION OF FISSION PRODUCTS IN IRRADIATED URANIUM OXIDE. Bulovic, V. F. (Boris Kidric Inst. of Nuclear Sciences, Vinca, Yugoslavia). J. Radioanal. Chem.; 4: 99-107(Jan 1970).

The burnup of $^{235}U$ was determined in two uranium oxide samples (0.713 and 89.9% $^{235}U$ in mixture) irradiated simultaneously with a cobalt monitor, from the amounts of $^{95}Zr$, $^{103}Ru$, $^{137}Cs$, $^{140}Ba$, and $^{144}Ce$ obtained by measuring the intensities of the corresponding gamma radiations. The samples were irradiated for 23 days, and the fission products were measured after cooling for 100 days, nondestructively, by means of a Ge(Li) spectrometer. The integrated neutron flux was determined by measuring the produced $^{60}Co$ in the cobalt monitor. The burn-up in both samples was determined by measuring the intensity of eight gamma energies (0.5 to 1.6 MeV). The determined values were in good agreement. The standard deviation of the mean value ($N_f$) is 5%. The atom per cent fission of $^{235}U$ in both samples, calculated according to $N_f$, differed by 1%. The measured $\sigma_f$ for $^{235}U$ was in good agreement with the data reported in the literature. (auth)

**16465** USE OF DEUTERONS AND TRITONS OF LOW ENERGIES FOR THE DETERMINATION OF CARBON AND OXYGEN PRESENT ON THE SURFACE OF METALLIC SAMPLES. Barrandon, J. N. (Centre d'Etude de Chimie Metallurgique, Vitry/Seine, France); Quaglia, L.; Debrun, J. L.; Cuypers, M.; Robaye, G. J. Radioanal. Chem.; 4: 115-26(Jan 1970). (In French).

The oxygen and carbon concentrations on metal surfaces were determined by two methods. The first method was based on the detection of the emitted particles in the $^{12}C(d,p)^{13}C$ and $^{16}O(d,p)^{17}O$ reactions, the second one on the measurement of the induced radioactivities in the $^{12}C(d,n)^{13}N$ and $^{16}O(t,n)^{18}F$ reactions, respectively. The results, obtained by the two different methods for high purity metals, were in agreement. A type of error which exists in the determination of trace amounts of carbon and oxygen in pure metals by combustion and reductive fusion was quantitatively demonstrated. This error exists also in the determination of oxygen by 14-MeV neutron bombardment. (auth)

**16466** A COMPILATION OF SECOND ORDER REACTION INTERFERENCES. PART II. Op de Beeck, J. P. (Univ. of Ghent). J. Radioanal. Chem.; 4: 137-55(Jan 1970).

A compilation of calculated interferences of 40 second order reaction chains is a continuation of studies on activation analysis. The data are calculated for a thermal neutron flux of $5 \times 10^{12}$ n · cm$^{-2}$ sec$^{-1}$, and a thermal to epithermal neutron flux ratio of 100. (P.C.H.)

**16467** AN ACTUAL CASE OF GLASS DEBRIS IDENTIFICATION BY NAA IN AN AUTOMOBILE ACCIDENT. Atalla, L. T.; Lima, F. W. (Instituto de Energia Atomica, Sao Paulo, Brazil). Radiochem. Radioanal. Lett.; 3: 13-22(11 Feb 1970).

The origin of glass fragments, found during an investigation of an accident between two cars, was established by neutron activation analysis. It was possible to ascribe responsibility for the accident based on that identification together with the other general evidence usually considered in such cases. Besides γ spectrometry, specific activities were also used as criteria for the examination of samples. (auth)

**16468** TRACER INDIUM DETERMINATION IN RAIN SAMPLES BY NEUTRON ACTIVATION AND RADIOCHEMICAL ANAL-

YSIS. Bhatki, K. S.; Dingle, A. N. (Univ. of Michigan, Ann Arbor). Radiochem. Radioanal. Lett.; 3: 71-9(11 Feb 1970).

The experimental procedure for determining a few parts per trillion of indium from rain samples by neutron activation is described. The preconcentration of ng amounts of indium from a liter of rainwater on hydrated ferric oxide and the post irradiation radiochemical purification of indium from arsenic, manganese, sodium, chlorine, and lanthanum employing homogeneous precipitation, solvent extraction, and ion exchange is discussed. (auth)

16469 ASSOCIATION OF THE METHODS OF ACTIVATION ANALYSIS AND ISOTOPE DILUTION FOR THE DETERMINATION OF COPPER IN CHEMICAL REAGENTS. Lima, F. W.; Atalla, L. T. (Instituto de Energia Atomica, Sao Paulo, Brazil). Radiochem. Radioanal. Lett.; 3: 23-30(11 Feb 1970).

Sensitivity of isotope dilution analysis is limited by the method used for determination of the recovered mass of the labeled element added as tracer. Determination of this mass by activation analysis increases sensitivity of isotope dilution. This method was applied to the analysis for copper, at ppB level, in analytical grade reagents. (auth)

16470 DETERMINATION OF URANIUM IN ZIRCONIUM AND ZIRCALOY BY NEUTRON ACTIVATION. Yoshida, Hiroyuki; Yonezawa, Chushiro (Japan Atomic Energy Research Inst., Tokai). Jap. Anal.; 19: 238-41(Feb 1970). (In Japanese).

A method is described for the determination of small amounts of uranium in zirconium and Zircaloy by neutron activation. The sample and standard solution containing known amounts of uranium are irradiated. After cooling for one day, the sample is dissolved in hydrochloric acid and hydrofluoric acid. The solution is evaporated, and treated with sulfuric acid to remove excess fluorides. After dissolving the residue in 1N hydrochloric acid, $^{239}Np$ is separated by 2-thenoyltrifluoroacetone extraction. Gamma radioactivity of $^{239}Np$ is measured using an NaI(Tl) scintillation counter. The proposed method was successfully applied to several standard samples containing more than 2 ppM of uranium. (auth)

16471 THE DETERMINATION OF MOLYBDENUM IN VANADIUM PENTOXIDE BY NEUTRON ACTIVATION ANALYSIS. Adams, F.; Hoste, J. (Univ. of Ghent). Radiochem. Radioanal. Lett.; 3: 31-8(11 Feb 1970).

Down to 20 ppB of molybdenum was determined in vanadium pentoxide powder and single crystals. $^{99}Tc$, daughter of $^{99}Mo$, was separated by distillation and measured by scintillation spectrometry. (auth)

16472 STUDY OF THE DISTRIBUTION OF OXYGEN IN OXIDE FILMS BY MEANS OF THE $^{18}O(p,\gamma)^{19}F$ NUCLEAR REACTION. Skakun, N. A.; Kharkov, O. N. At. Energ. (USSR); 27: 351-2(Oct 1969). (In Russian).

Oxidation processes of metals were examined by means of the resonance nuclear reaction $^{18}O(p,\gamma)^{19}F$ on the oxide film of zirconium, in order to obtain information about the surface phenomena that take place on metals during reactions with the oxidizing medium. The targets consisted of pure zirconium oxidized at a pressure of 300 mm and a temperature of 500°C with water vapor containing 39.4% $^{18}O$. The study involved measurement of the resonance yield of the $\gamma$ radiation of the above reaction by an accelerated proton beam. The higher the proton energy, the deeper is the oxide layer in which the reaction takes place, while the $\gamma$ quantum yield is directly proportional to the concentration of $^{18}O$. Thus by changing the proton energy and measuring the $\gamma$ quantum yield it is possible to determine the depth distribution of oxygen in the layer, as no reaction with $^{18}O$ takes place in the examined energy range. (TTT)

16473 ACTIVATION ANALYSIS WITH $^{252}Cf$. Ricci, Enzo; Handley, T. H. (Oak Ridge National Lab., Tenn.). Anal. Chem.; 42: 378-82(Mar 1970).

It is shown that a $^{252}Cf$ spontaneous-fission neutron source placed in the center of a 1-foot cube of moderator can be considered a portable, maintenance-free, quasi reactor by the activation analyst. One such source was calibrated by activation to have a $4\pi$ neutron emission intensity of $8.6 \times 10^8$ sec$^{-1}$ i.e., 0.37 mg $^{252}Cf$, the thermal, epithermal, and fast neutron fluxes in the moderating cube were $9.7 \times 10^6$, $9.4 \times 10^4$, and ~$10^3$ cm$^{-2}$ sec$^{-1}$ per mg $^{252}Cf$, respectively, and the cadmium ratio 7.6. The average cross section for the reaction $^{27}Al(n,\alpha)^{24}Na$ was calculated for the $^{252}Cf$ neutron spectrum to be 1.35 mb; use of analogous values, corresponding to the $^{235}U$ fission spectrum in $^{252}Cf$ calculations is shown to result in serious error. A pneumatic activation analysis system was built; interference-free sensitivities and detection limits, determined for 13 elements of geological and biomedical interest, were found quite satisfactory for activation analysis. The system was also reliable and had good irradiation and counting-position reproducibilities. As a consequence, a mobile, power-free, maintenance-free, sensitive and reliable activation analysis unit is suggested for field work and discussed. Increasing demand is also predicted for more and larger $^{252}Cf$ sources for use both in American biomedical centers and small universities, and in research institutes of other countries, where maintenance of a nuclear reactor is not economically feasible. (auth)

16474 STUDY OF THE PHOTOACTIVATION ANALYSIS: DETERMINATION OF ARSENIC, RUBIDIUM, AND NIOBIUM. Oka, Yoshinaga; Kato, Toyoaki (Tohoku Univ., Sendai). Res. Rep. Lab. Nucl. Sci., Tohoku Univ.; 1: No. 2, 126-28(Dec 1968). (In Japanese).

More than 75 elements were irradiated with 20 to 60 MeV bremsstrahlung; and the type of nuclear reaction, reaction yield, and sensitivity were examined. In order to correct the variation of flux intensity and the difference of flux distribution, an internal-monitor method was adopted. That is, the peak area of appropriate $\gamma$ ray of the radioactive nuclide produced from the element in question was measured, and compared with that of nuclide from the element added as an internal monitor. In estimating As by comparison with the internal monitor Se, $^{74}As$, which was produced from As by irradiating with 20-MeV bremsstrahlung, and $^{76}As$ produced from Se under the same condition were compared. When $R_W$ represents the As/Se ratio and $R_{A_s}$ represents the radioactivity ratio, $^{74}As/^{76}As$, which was measured immediately after irradiation; $(1.4 \pm 0.02) \times 10^{-2}$ was obtained as the average of $R_W/R_{A_s}$ ratios of five samples. In estimating Rb with the internal monitor Sr, $(6.0 \pm 0.13) \times 10^{-3}$ was obtained as the average of $R_W/R_{A_s}$ ratios of five samples using $^{84}Rb$ and $^{83}Rb$, which were product nuclides of Rb and Sr. In estimating Nb with the internal monitor Mo, $(1.0 \pm 0.02) \times 10^{-2}$, the average of $R_W/R_{A_s}$ ratios of five samples was obtained using $^{92m}Nb$ and $^{93m}Nb$, which were product nuclides of Nb and Mo. (NSA of Japan)

16475 NUCLEAR REACTIONS AND THE ANALYTICAL-CHEMISTRY APPLICATION. Oka, Yoshinaga; Kato, Toyoaki (Tohoku Univ., Sendai). Res. Rep. Lab. Nucl. Sci., Tohoku Univ.; 1: No. 1, 77-81(1968). (In Japanese).

The present experiments were designed to obtain basic information for the application of photonuclear reactions to activation analysis by means of the determination of yield in various reactions occurring in the region of high-energy bremsstrahlung and the investigation of production rates in ($\gamma$, xnyp) reactions. Various elements from Be to Bi were irradiated with bremsstrahlung of energy from 30 to 67 MeV for periods of from 1 to 5 hr. From the $\gamma$ spectrometry of the residual nuclei, yield was calculated and the relation between yield, maximum energy, and the production rate was studied. The yield in ($\gamma$,n) reactions reached near saturation beyond 30 MeV. However, the yield in other reactions with emission of many particles increased markedly with irradiation energy. The yield in ($\gamma$,2n) and ($\gamma$,pn) reactions attained several tens of % of that for the ($\gamma$,n) reaction to make possible the application of photonuclear reactions for activation analysis. (NSA of Japan)

16476 NEUTRON-CAPTURE GAMMA-RAY ACTIVATION ANALYSIS. Lombard, Stewart Matthew. Seattle; Univ. of Washington (1969). 97p.

Thesis.

The apparatus for neutron-capture $\gamma$ activation analysis is designed to optimize analytical sensitivity and accuracy. A filter/collimator located within a vertical beam tube of the University of Washington Nuclear Reactor produces a thermal neutron flux of $1.1 \times 10^7$ n/cm$^2$/sec at the sample with low fast neutron and $\gamma$ fluxes. A high-resolution chopper system modulates the neutron beam and gates the multichannel analyzer, allowing automatic subtraction of background radiation during analysis. The performances of a NaI(Tl) scintillation detector and two Ge(Li) semiconductor detectors with the apparatus are compared on the basis of resolution, efficiency, and limits of detection; and the latter are shown to be superior for this application. The detection limits of the method for 18 elements in aqueous solution range from 0.2 ppM for Gd to 500 ppM for Se with the 20 cm$^3$ coaxial Ge(Li) diode. The method is applied to the analysis of four rare earth ores in which Sm and Gd are determined to less than ± 5% relative error in samples weighing 10 to 100 mg. (Disser. Abstr.)

16477 THE DETERMINATION OF BROMINE IN TERRESTRIAL AND EXTRATERRESTRIAL MATERIALS BY NEUTRON-ACTIVATION ANALYSIS. Lieberman, Kenneth Warren. Lexington, Ky.; Univ. of Kentucky (1967). 180p.

Thesis.

A method was developed to accurately determine Br in a silicate matrix for abundance levels of 1 ppM or less by neutron activation.

Irradiated samples were dissolved in a $Na_2O_2$–NaOH fusion mixture, and Br was separated by treatment with a series of selective oxidizing and reducing agents in conjunction with a solvent extraction procedure. The total time required for separation of the Br was thirty minutes. Analytical determinations for Br were conducted on specimens from the major chondrite and achondrite classifications, australites and other tektites, igneous rocks from the Palisades Sill and the Oslo plutonic sequence, specimens from other intrusive and extrusive igneous formations, eight standard rocks, some possible upper mantle materials, and on two deep-sea sediment cores. Br was found to be fractionated among the three major chondrite groups; carbonaceous, enstatite, and ordinary with progressive depletion in going from carbonaceous to the ordinary chondrites. Within the three carbonaceous chondrite sub-groups Br does not behave as a typical depleted trace element. Br is impoverished in the Type II carbonaceous chondrite with respect to the Type I, but is enriched in the Type III with respect to Type II. Br was depleted during fractionation of a magma in the formation of the Oslo plutonic sequence, and was enriched during the fractionation of the Palisades magma. The geochemical behavior of Br during differentiation of the Palisades Sill is comparable to the behavior of F in the Great Lake Sheet. Both the Great Lake and Palisades are derived from the tholeiitic magmas. It was determined that Br has an approximate average igneous crustal abundance of 1.42 ppM, which is lower than previous estimates. The abundance of Br in igneous rocks is relatively uniform and for the majority of analyses ranged from 0.15 to 1.5 ppM. The Br abundance data for the australites suggest a geographical trend with generally higher concentrations in the east and a progressive depletion toward the west. These data are consistent with an origin to the southeast of Australia. (Disser. Abstr.)

**16478** DETERMINATION OF C AND O CONTENT IN HUMIC ACID BY MEANS OF A PHOTONUCLEAR REACTION. Kasymov, A. K.; Masagutov, V. S. (Tashkent State Univ.). Dokl. Akad. Nauk Uzb. SSR; No. 4, 18-19(1969). (In Russian).

The carbon and oxygen contents in a humic acid were determined using compressed specimens placed inside an acceleration chamber and irradiated by bremsstrahlung $\gamma$ quanta with a maximum energy of 24.5 MeV. The results of the $(\gamma,n)$ reaction determination of carbon and oxygen content in humic acid revealed 59.57% and 28.46% of C and O, respectively. (R.V.J.)

**16479** DETERMINATION OF COPPER, ARSENIC, AND ANTIMONY IN PURE PHOSPHORUS BY NEUTRON ACTIVATION ANALYSIS. Bando, Shoji (Japan Atomic Energy Research Inst., Ibaraki); Kishi, Hajime. Jap. Anal.; 19: 17-22(Jan 1970). (In Japanese).

A method has been developed for the determination of microgram quantities of copper, arsenic, and antimony in pure phosphorus by neutron activation analysis. The sample (0.2 g) irradiated for 20 min in JRR-2 pneumatic tube (neutron flux: $8 \times 10^{13}$ n/cm$^2$·sec) was dissolved with nitric acid after addition of 10 mg each of copper, arsenic, and antimony as the carriers. The three elements were removed from phosphorus as sulfides and separated mutually by anion exchange chromatography. Radioactivities were measured by a gas-follow counter and a $\gamma$ spectrometer. The mean chemical yields were 86% for copper, 85% for arsenic, and 79% for antimony. As little as $7 \times 10^{-4}$ $\mu$g of copper, $5 \times 10^{-4}$ $\mu$g of arsenic, and $9 \times 10^{-4}$ $\mu$g of antimony could be determined. (auth)

**16480** DETERMINATION OF $^{68}$Zn–$^{64}$Zn RATIO IN SPHALERITE BY NON-DESTRUCTIVE NEUTRON ACTIVATION ANALYSIS. Santos, G. Jr.; Torralba, O. (Philippine Atomic Research Center, Quezon City). Philippines Nucl. J.; 2: 123-8(1969).

Nondestructive neutron activation analysis in conjunction with gamma spectrometry was used to determine the $^{69m}$Zn/$^{65}$Zn ratio in sphalerite, which is a measure of the $^{68}$Zn/$^{64}$Zn ratio. Sphalerite and zinc standards were irradiated in a thermal neutron flux of approximately $2.3 \times 10^{12}$ n/cm$^2$ sec for seven hours. The samples were counted two days after irradiation. The gamma spectra of sphalerite and zinc standards were obtained with the use of a multichannel analyzer. The spectrum-stripping technique was applied in subtracting the undesirable 0.51-MeV photopeak which was located near the 13.8-hour $^{69m}$Zn 0.44-MeV photopeak. A single channel analyzer was used to measure the activity of the 1.114-MeV photopeak of the 245-day $^{65}$Zn. The results showed that the isotopic abundance of zinc in sphalerite differs from the conventional abundance. It is suspected that isotopic fractionation of zinc occurred during ore deposition. (auth)

**16481** PHOTON SELF-ABSORPTION CORRECTIONS FOR THE MINIMIZATION OF SYSTEMATIC ERRORS IN 14-MeV NEUTRON ACTIVATION ANALYSIS. Nargolwalla, S. S.; Crambes, M. R.; Suddueth, J. E. (National Bureau of Standards, Washington, D. C.). Anal. Chim. Acta; 49: 425-36(Mar 1970).

In comparative 14-MeV neutron activation analysis for oxygen, systematic errors are evidenced if attenuation of incident neutrons and induced $\gamma$ radioactivity by a thick sample is ignored. The general case of measurement where photopeaks resulting from either direct nuclear transitions or from positron annihilation are counted was considered. A quantitative evaluation of these attenuation processes is presented. The results show that the photon attenuation correction factor is related to the difference between the calculated linear absorption coefficients for sample and standard through a simple exponential expression. The slopes of the respective correction factor lines were compared with that for integral $\gamma$ counting in oxygen analysis. Differences in the magnitudes of the slopes are discussed. The results were consistent with the removal cross-section theory describing 14-MeV neutron attenuation over a wide range of threshold energies. Typical analyses of Standard Reference Materials, with these correction factors, are given. (auth)

# Inorganic, Organic, and Physical Chemistry

*Refer also to abstracts 16567, 16587, 16604, 16651, 16652, 16654, 16671, 17190, 17222, 17265, 18038, 18054, and 18587.*

**16482** (ANL–7594) EFFECT OF ANIONIC CONSTITUENTS ON THE SURFACE IONIZATION OF LITHIUM SALTS. Sloth, Eric N. (Argonne National Lab., Ill.). Jul 1969. Contract W-31-109-eng-38. 130p. Dep. CFSTI.
Thesis. Submitted to Illinois Inst. of Tech., Chicago.

The validity of the Saha–Langmuir theory of surface ionization was demonstrated for the lithium–rhenium system over a temperature range 1200 to 2600°K. The effective surface-ionization work function obtained for rhenium was 5.21 ± 0.01 eV, compared to the measured thermionic-emission work function of 4.98 ± 0.03 eV. At relatively high temperatures, the temperature dependence of the lithium surface-ionization current from all molecules studied was identical to that obtained from lithium atoms. Incomplete dissociation of lithium chloride and lithium bromide can account for the lithium ionization threshold temperatures being well above that for surface ionization of lithium atoms. Dissociation energies of $D_{LiCl(g)} = 4.9 \pm 0.1$ eV (1300 to 1700°K) and $D_{LiBr(g)} = 4.4 \pm 0.1$ eV (1150 to 1400°K) were obtained. Enhanced emission of lithium ions was observed in the temperature range where incomplete dissociation of lithium iodide was expected due to a rhenium–iodine interaction shifting the dissociation equilibrium to lower temperatures. For lithium nitrate incident on rhenium, several lithium rhenates were formed corresponding to $Li_2ReO_4$, $LiReO_4$, and $LiReO_3$. Lithium sulfate decomposed to give beams of dilithium oxide and lithium atoms. The temperature dependence of the lithium surface-ionization current was the sum of the individual ion currents from lithium atoms and dilithium oxide. A desorption energy of 4.13 eV was obtained for residual-gas oxygen on rhenium using surface-ionization techniques. (189 References) (auth)

**16483** (BARC–402) ORGANIC MATERIALS IN THE MARINE ENVIRONMENTS AND THEIR INTERACTIONS WITH SOME METAL IONS. Koshy, Elizabeth; Ganguly, A. K. (Bhabha Atomic Research Centre, Bombay (India)). 1969. 124p. Dep. CFSTI (U. S. Sales Only).

Studies were made on the presence of organometallics in the dissolved state and in humus material. Attempts were made to identify the amino acids that are present in the dissolved organics and the humus material and to examine the physicochemical interactions of the humic acid, isolated from the sediment, with some biochemically significant metallic ions. For carrying out detailed investigations, dissolved organic matter was separated from seawater of the Bombay Harbour Bay. Suitable methods were developed to concentrate the dissolved organic fraction from the seawater. A sample of humic acid was prepared from the coastal sea bed sediment of the Bombay Harbour Bay and purified by electrodialysis at 200 v. The trace metallic component in the highly purified humic acid was also invertigated. Pickup and solubilization of the alkali metals Cs and K; the alkaline earths Ba and Sr; the divalent elements Zn, Mn, and Cu; the trivalent element Y; the transitional elements Fe and Co; the rare earth Ce, and the tetravalent element Zr were selected to study the interaction with humic acid. (P.C.H.)

**16484** (IJS–248) SYNTHESIS AND REACTIVITY OF URANIUM SULFIDES. Komac, Milos (Nuklearni Institut Jozef Stefan, Ljubljana (Yugoslavia)). Oct 1969. 34p. (In Slovenian). Dep. CFSTI (U. S. Sales Only).

Various syntheses and the reactivity of uranium monosulfide

are described. Best results were obtained by the direct synthesis from the elements. Reaction products were analyzed by chemical, x-ray, and differential thermal analyses. The results of sintering of US in a vacuum at temperatures from 1600 to 1750°C are given. Investigations on the systems US–CaS and US–BaS are described. It was concluded on the basis of x-ray and differential thermal analysis, that in both systems mutual solubility of the components does not exceed 5%. The occurrence of a new phase in both systems was established. In the system US–CaS, this new phase may be described as having primitive cubic unit cell with a = 8.497 Å. (auth)

**16485** (IS–2100, Sect. C) CHEMISTRY DIVISION. Hansen, R. S.; Corbett, J. D.; Banks, C. V.; (and others) (Ames Lab., Iowa). 81p.

Progress is reported on studies of reactions and properties of metals in low oxidation states. A study of the existence and structure of phases in the metal-rich region of the Zr–S system was completed. Studies of the Tl–F system via infrared spectroscopy of matrix-isolated molecules yielded two stretching frequencies for the $Tl_2F_2$ dimer. Kinetics for the isotopic exchange of bromide and chloride ligands were evaluated at 25 and 35° in methanol for a series of neutral trans-dihalo complexes of Pt(II) by means of the radioactive tracers $^{82}Br$ and $^{36}Cl$. A detailed x-ray structure analysis of $[(CH_3)_4N]_3Nb_6Cl_{18}$, containing the $Nb_6Cl_{18}$ unit in its highest known oxidation state, was completed. A variety of tungsten halide cluster compounds were prepared and their structures studied via ir spectra. The ir spectra of 10 crystalline heavy transition metal pentahalides ($M_2X_{10}$, where M = Ta, Nb, Re, Mo, W and X = Cl, Br, I) were measured at 77°K. ENDOR signals slightly above the spectrometer noise level were obtained for x-irradiated single crystals of succinic acid at 77°K. The partition behavior of the lanthanides between aqueous mineral acid phases and the bifunctional extractants, methylenebis[dialkylphosphine oxides] was investigated. The possibility of determining the lanthanides by gas chromatography after extraction from aqueous phases into cyclohexane solutions of various fluorinated β-diketones was investigated. The spectra of the ligands and chelates of nickel and copper dimethylglyoxime, diaminoglyoxime, α-furil-dioxime, and diphenyl glyoxime were obtained. Studies on the gravimetric determination of nickel with 1,2-cycloheptanedionedioxime indicated that an empirical correction factor should be used in the calculation of results. A new method for the column chromatographic separation and spectrophotometric measurement of small amounts of uranium(VI) was developed. Research was continued on the solvent extraction of metal ions by Alamine 336 thiocyanate in toluene and on chromatographic separations using a column packed with Alamine thiocyanate on a solid support. Various thermodynamic properties of rare earth chlorides, nitrates, and perchlorates were studied. Research was continued on the determination of oxygen in metals by 14 MeV neutron activation. Procedures for the removal of Os and Ru from platinum by distillation were tested. (J.G.B.)

**16486** (ORNL–4449, pp 96-163) CHEMISTRY. Grimes, W. R. (Oak Ridge National Lab., Tenn.).

Topics covered include: chemistry of the MSRE, fission product behavior, properties of alkali fluoroborates, physical chemistry of molten salts, chemistry of molten-salt reactor fuel processing technology, and development and evaluation of analytic methods for molten-salt reactors. (M.C.G.)

**16487** (ORO–2124-22) PROPERTIES AND STRUCTURES OF SOLVATES OF METAL CHELATES ENCOUNTERED IN SOLVENT EXTRACTION SYSTEMS. Progress Report, January 1, 1969–December 31, 1969. Wagner, William F.; Sands, Donald E. (Kentucky Univ., Lexington. Dept. of Chemistry). 22 Jan 1970. Contract AT(40-1)-2124. 6p. Dep. CFSTI.

Complexes of rare earths that form in various solvent extraction systems are discussed. (M.C.G.)

**16488** (UCRL-Trans-10445) PREPARATION AND STRUCTURE OF THE BERYLLIUM BORIDE $Be_4B$. Becher, H. J.; Schafer, A. Translated for Univ. of California Lawrence Radiation Lab., Livermore, from Z. Anorg. Allg. Chem.; 318: 304-12(1962). 8p. Dep. CFSTI.

An abstract of this paper, prepared from the original language, appeared as NSA 17: 34464.

**16489** THE KINETICS OF THE GAS PHASE INTRAMOLECULAR ELIMINATION OF ISOBUTENE FROM 2-$d_1$-TRIISOBUTYLALUMINUM AND THE DEUTERIUM ISOTOPE EFFECT IN REACTIONS INVOLVING CYCLIC TRANSITION STATES. Egger, Kurt W. (Monsanto Research S. A., Zurich). Int. J. Chem. Kinet.; 1: 459-72(Sep 1969).

The gas phase thermal decomposition of monomeric 2-$d_1$-triisobutylaluminum was studied for temperatures ranging between 102.4 and 186.3°C in the presence of excess ethylene. The principal reaction products were isobutene and mixed 2-$d_1$-trialkylaluminum compounds containing ethyl, isobutyl, and small amounts of n-butyl groups. The reaction is apparently homogeneous and obeys the first order rate law, yielding the following Arrhenius relationship: $\log k_{elim}\ (sec^{-1}) = 11.1 - 27.2/\theta$ where $\theta$ equals $4.58 \times 10^{-3}T(°K)$ in units of Kcal/mole. The cyclic 4-center nature of the transition state proposed earlier was unequivocally demonstrated by deuterium labeling. Mass-spectral analyses show that the isobutene formed contains no deuterium. The hydrolyses products of the mixed trialkylaluminum formed during the reaction consist of monodeuteroethane and 2-$d_1$-isobutane. The observed negative entropy of activation of ~12 cal/°-mole agrees with prediction and implies a reasonably tight transition state structure. Combined with the corresponding data for the nondeuterized Al (i-bu)$_3$ reported earlier, these data result in a primary kinetic deuterium isotope effect of $k_H/k_D = 1.3 \times 10^{0.6/\theta}$ corresponding to a ratio of the isotopic rate constants of 3.7 at 25°C. This result is in excellent agreement with a predicted value of $1.4 \times 10^{0.7/\theta}$, and it is in line with literature data on similar reactions involving cyclic transition state complexes. An appendix presents theoretical aspect of calculation of the D isotope effect. (BBB)

**16490** ATOMIC WEIGHTS OF ELEMENTS, 1967. Wichers, E.; Gueron, J.; Fujiwara, S.; Greenwood, N. N.; Peiser, H. S.; Spaepen, J.; Thode, H. G.; Wapstra, A. H.; Cameron, A. E.; Flerov, G. N.; Roth, E.; Svec, H. J. Pure Appl. Chem.; 18: 571-9(1969).

In the general review and recalculation of atomic weights that accompanied the change to the $^{12}C$ scale in 1961, the values assigned to a number of the elements were derived wholly or in part from chemical ratios involving silver and Br. Because slight changes were made in the atomic weights for these two elements in 1965, the values of all elements that might be affected by the changes have been reexamined. None of the atomic weights thus recalculated was changed by as much as one unit in the last decimal place. The reasons for these changes and references to the measurements from which the atomic weights were calculated are discussed. (P.C.H.)

**16491** KINETICS AND ISOTOPE EFFECT OF AMMONIA SYNTHESIS OVER RUTHENIUM. Aika, Ken-ichi; Ozaki, Atsumu (Tokyo Inst. of Tech.). J. Catal.; 16: 97-101(Jan 1970).

The kinetics and isotope effects of ammonia synthesis over a ruthenium catalyst were investigated at 346 to 410°C under reduced pressures. A rate equation $R = kP_{N_2}P_{H_2}^{-1}P_{NH_3}^{0}$ was obtained. Deuterium isotope effect was hardly detected. It was concluded that the rate of synthesis is controlled by dissociative absorption of nitrogen. The lack of isotope effect over Ru was successfully interpreted from the view previously proposed for the synthesis over Fe and applied to Mo. Relevant works are also discussed. (auth)

**16492** REACTIONS OF IRON CARBIDES WITH LIQUID SODIUM. Charles, R. G.; Yannopoulos, L. N.; Haverlack, P. G. (Westinghouse Research Labs., Pittsburgh). J. Inorg. Nucl. Chem.; 32: 447-56(Feb 1970).

The technique of thermomagnetic analysis was used to investigate the reactions of $Fe_3C$, $Fe_{20}C_9$, and $Fe_{2.82}Mn_{0.18}C$ with liquid sodium at elevated temperatures. For comparison, a few similar experiments were carried out with lithium or potassium. The results indicate that there is no direct reaction between the carbides and sodium, at least at temperatures below those where the pure carbides decompose by pyrolysis. Carbide preparations that have enhanced heat stability due to the presence of trace nonmetallic impurities, however, decompose at significantly lower temperatures when in contact with liquid sodium, due to removal of the stabilizing substances by reaction with the liquid metal. It was found, in contrast with the sodium results, that a direct reaction between $Fe_3C$ and liquid lithium does occur. (auth)

**16493** DIAGRAMMY SOSTOYANIYA SILIKATNYKH SISTEM. SPRAVOCHNIK. VYPUSK PERVYI DVOINYE SISTEMY IZDANIE VTOROE, DOPOLNENNOE. (Phase Diagrams of Silicate Systems. Handbook. Second Improved and Supplemented Edition). Toropov, N. A.; Barzakovskii, V. P.; Lapin, V. V.; Kurtseva, N. N. Leningrad; Izdatel'stvo Nauka Leningradskoe Otdelenie (1969). 825p.

Information is included on binary systems of silicates, aluminates, germanates, titanates, zirconates, phosphates, vanadates, niobates, tantalates, molybdates, tungstates, ferrites, fluorides, and rare earth oxides, and systems containing Cr, Mn, and U. These systems are the main materials of contemporary technology for the production of various ceramics, refractory materials, and electrical and radiotechnical construction materials. Phase diagrams are given for the systems along with stability and strength of various phases of these materials and chemical

composition. Certain physical constants (optical properties, structural characteristics, etc.) are also included. 816 systems in all are described. 1743 references. (tr-auth)

**16494** THE REACTION CAPABILITY OF OXYGEN ON THE SURFACE OF COMPLEX OXIDES. I. ISOTOPIC EXCHANGE OF OXYGEN ON MOLYBDENUM OXIDE CATALYSTS. Boreskov, G. K.; Muzykantov, V. S.; Panov, G. I.; Popovskii, V. V. (Inst. of Catalysis, Novosibirsk, USSR). Kinet. Katal.; 10: 1043-51 (Sep-Oct 1969). (In Russian).

Isotopic exchange of oxygen on the surface of complex cobalt molybdenum and iron molybdenum oxides was studied in relation to chemical composition, thermodynamic conditions, and previous treatment. It was established that the limiting stage in heteroexchange of molecular oxygen with the oxides of molybdenum and iron and the molybdates of iron and cobalt is adsorption–desorption, if the content of oxygen in the surface layer is in equilibrium. The removal of oxygen from the surface of iron molybdate led to the formation of active sites, on which homomolecular exchange occurs without heteroexchange. (tr-auth)

**16495** THE HEPTAVALENT STATE OF TRANSURANIC ELEMENTS AND THEIR POSITION IN PERIODIC SYSTEM OF D. I. MENDELEEV. Krot, N. N.; Gel'man, A. D.; Spitsyn, V. I. (Inst. of Physical Chemistry, Moscow). Zh. Neorg. Khim.; 14: 2633-9(Oct 1969). (In Russian).

The most important properties of neptunium and plutonium in the heptavalent state are surveyed. On this basis the position of these elements in the third subgroup of the seventh and eighth groups of the Mendeleev periodic table is justified. (tr-auth)

**16496** INVESTIGATION OF CERTAIN CARBONATE COMPLEXES OF THORIUM BY THE METHOD OF INFRARED-SPECTROSCOPY. Kharitonov, Yu. Ya.; Molodkin, A. K.; Balakaeva, T. A. (Inst. of General and Inorganic Chemistry, Moscow). Zh. Neorg. Khim.; 14: 2761-7(Oct 1969). (In Russian).

Absorption spectra of the following carbonate complexes of thorium and their thermal products were studied: $Na_4Th(CO_3)_5 \cdot 12H_2O$ (I); $Na_4Th(CO_3)_5 \cdot 2OH_2O$ (II); $Th(OH)_2CO_3 \cdot 2H_2O$ (III); $(CN_3H_6)_4Th(CO_3)_5 \cdot 4H_2O$ (IV); and, $[Co(NH_3)_6]_2Th(CO_3)_5 \cdot 4H_2O$ (V). It was found that in compound (I) only bidentate (cyclic or bridge) carbonate groups are present. The spectra of thermal products of (I) and (III) at 500 to 600°C and (I) to 900°C are given. Both bidentate and monodentate carbonate groups were found in compounds (II, IV, and V). (tr-auth)

**16497** AQUOOXALATE COMPOUNDS OF TETRAACID URANYLS. Shchelokov, R. N.; Belomestnykh, V. I. (Inst. of General and Inorganic Chemistry, Moscow). Zh. Neorg. Khim.; 14: 2832-8(Oct 1969). (In Russian).

A series of derivatives of aquooxalatouranylates were synthesized and certain physical and chemical properties studied. Solubility of the complexes in water increases with an increase in temperature. The relationship of solubility of the derivatives and properties of the cation was studied. A scheme for the thermal decomposition of aquooxalatouranylates of alkali metals is proposed. (tr-auth)

**16498** MEASUREMENT OF MOLYBDENUM OXIDES IN MIXTURES AND COMBINATIONS. Bourret, Pierre; Lecuire, Jean-Marie; Weis, Catherine. (Nancy Univ.). Chim. Anal. (Paris); 52: 48-52(Jan 1970). (In French).

Molybdenum oxides are soluble in concentrated neutral or alkaline solutions of sodium periodate. The sodium periodate oxidizes all the lower valencies into Mo(VI) and is reduced to iodate. The measurement of the molybdates and iodates thus formed shows the average degree of oxidization of the molybdenum in the sample. (France)

**16499** EFFECT OF 4,4-DIDEUTERATION OF REDUCED NICOTINAMIDE–ADENINE DINUCLEOTIDE PHOSPHATE ON THE MIXED FUNCTION OXIDASES OF HEPATIC MICROSOMES. Holtzman, Jordan L. (National Cancer Inst., Baltimore). Biochemistry; 9: 995-1001(17 Feb 1970).

It was postulated for hepatic microsomal mixed-function oxidases that the electrons are transferred along an electron chain containing a flavoprotein, reduced nicotinamide–adenine dinucleotide phosphate–cytochrome c reductase, and the iron of cytochrome P-450. Sih, G. J., Tsong, Y. Y., and Stein, B. [J. Amer. Chem. Soc.; 90: 5300(1968)] suggested, on the basis of kinetic evidence, that in the mitochondrial 11β-hydroxylase, reduced nicotinamide–adenine dinucleotide phosphate directly reduces the oxygen–oxygen bond. If such is the case, then the ratio of rates of hydroxylation for normal reduced nicotinamide–adenine dinucleotide phosphate to that of 4,4-dideuterio reduced nicotinamide–adenine dinucleotide phosphate (H:D) should be 2–3 due to the isotope effect of the deuterium. In hepatic microsomes the H:D is only 1.22 for ethylmorphine N-demethylase, 1.07 for aniline hydroxylase, and 1.12 for reduced nicotinamide–adenine dinucleotide phosphate–cytochrome P-450 reductase. The H:D of reduced nicotinamide–adenine dinucleotide phosphate–cytochrome c reductase is 2.00 when the deuterium is in the α position, but is 1.00 when it is in the β position. The H:D for endogenous and ethylmorphine-stimulated reduced nicotinamide–adenine dinucleotide phosphate oxidation were 0.98 and 1.18, respectively. Similarly for reduced nicotinamide–adenine dinucleotide phosphate stimulated oxygen uptake the H:D were 0.87 and 1.06, respectively. The failure to demonstrate a marked isotope effect clearly indicates that in the hepatic microsomes the proximal reducing agent of the oxygen–oxygen bond is an electron chain rather than a direct reduction by reduced nicotinamide–adenine dinucleotide phosphate. (auth)

**16500** KINETIC STUDIES OF THE HYDROLYSIS OF URANIUM MONOCARBIDE IN THE TEMPERATURE RANGE 30°C TO 90°C. Schuerenkaemper, A. (EURATOM C. C. R., Ispra, Italy). J. Inorg. Nucl. Chem.; 32: 417-29(Feb 1970).

Measurements of the reaction rate parameters of the hydrolysis of uranium carbide in water and water vapor were performed. For the temperature dependence of the rate parameter C in water an activation energy of 14.2 kcal/mol was found. Experimental values of the rate parameter k, measured for the reaction in water vapor as a function of temperature and vapor pressure p, were in good agreement with the relation $k = p/p_0 \cdot C$, where $p_0$ is the saturation pressure of water at the reaction temperature. This relation results from theoretical considerations, if it is assumed that the reaction in the vapor phase is determined by the superposition of the chemical reaction observed in liquid water and an adsorption process of water vapor on the uranium carbide. A multimolecular adsorption according to the BET equation was taken into consideration. (auth) (UK)

**16501** ISOTOPE EFFECT STUDIES ON ELIMINATION REACTIONS. VI. THE MECHANISM OF THE BIMOLECULAR ELIMINATION REACTION OF 2-ARYLETHYLAMMONIUM IONS. Smith, P. J.; Bourns, A. N. (McMaster Univ., Hamilton, Ont.). Can. J. Chem.; 48: 125-32(1 Jan 1970).

The mechanism of the elimination reaction of 2-arylethyltrimethylammonium ions with ethoxide ion in ethanol was examined using tracer and kinetic isotope effect techniques. Absence of exchange with solvent of both 2-phenylethyltrimethylammonium-2,2-$d_2$ bromide and 2-(p-trifluoromethylphenyl)-ethyltrimethylammonium-2,2-$d_2$ bromide and the observation of nitrogen isotope effects of 1.3 and 0.9%, respectively, have eliminated a two-step process involving a freely solvated carbanion intermediate for both salts. The observation of only a slight change in the magnitude of the nitrogen isotope effect when the solvent is changed from ethanol to water has also excluded a zwitterionic intermediate which is specifically hydrogen-bonded to the molecule of ethanol formed by removal of a β-hydrogen by ethoxide ion. Finally, tracer studies using α- and β-dideuterated substrates have eliminated the less probable reaction pathways involving ylide and carbene intermediates. It is concluded that the reaction of 2-arylethyltrimethylammonium salts with ethoxide ion is a concerted E2 process. (auth) (Canada)

**16502** ISOTOPE EFFECT STUDIES ON ELIMINATION REACTIONS. VII. THE STEREOCHEMISTRY OF ELIMINATION FROM 2-PHENYLETHYLAMMONIUM IONS. Bourns, A. N.; Frosst, A. C. (McMaster Univ., Hamilton, Ont.). Can. J. Chem.; 48: 133-7(1 Jan 1970).

The stereochemistry of the base-promoted elimination reactions of 2-phenylethyltrimethylammonium and 2-phenylethyldimethylanilinium ions, was investigated using both ethoxide ion in ethanol and t-butoxide in t-butyl alcohol as base-solvent systems. The proton magnetic resonance spectroscopic analysis of the deuterated styrene products formed from the reactions of the threo-2-phenylethylammonium-1,2-$d_2$ ions established that elimination proceeds more than 95% by an anti process. (auth) (Canada)

**16503** CHEMISTRY OF URANIUM INCLUDING ITS APPLICATIONS IN NUCLEAR TECHNOLOGY. Cordfunke, E. H. P. Topics in Inorganic and General Chemistry. Monograph 13. New York; American Elsevier Publishing Company, Inc. (1969). 262p. $16.75.

Topics covered include: extractive metallurgy of x uranium, uranium metal, interaction of uranium with metals, uranium hydride, oxides of uranium, uranium ions and their reactions, uranium salts, uranium halides, compounds of uranium with elements of Group IV, compounds of uranium with elements of Group V, chalcogenides of uranium, some applications of uranium chemistry in nuclear technology, and aspects of the analytical chemistry of uranium. (M.C.G.)

**16504** STRUCTURE OF THORIUM(IV) TETRAKIS-(NN-DIETHYLDITHIOCARBAMATE). Brown, D.; Holah, D. G.; Rickard, C. E. F. (Atomic Energy Research Establishment, Harwell, Eng.). J. Chem. Soc., A; 3: 423-5(1970).

X-ray structural analysis showed thorium(IV) tetrakis-(NN-diethyldithiocarbamate) to be the first example of a compound in which eight sulfur atoms are coordinated to a central metal atom. Crystals are monoclinic, space group C2/c with a = 19.16, b = 11.74, c = 16.11 Å, and $\beta = 116.42°$. The eight sulfur atoms coordinated to the thorium atom are arranged as a distorted dodecahedron in which the only symmetry is the crystallographically required two-fold axis. (auth) (UK)

**16505** MOLTEN SALTS. CHARACTERIZATION AND ANALYSIS. Mamantov, Gleb (ed.). New York; Marcel Dekker, Inc. (1969). 624p. $16.75.

Topics covered include: fundamental concepts in the chemistry of molten salts, experimental evidence for "complex ions" in some molten salt mixtures, phase equilibria in molten salt research, ionic interactions in molten salts, coordination equilibria of nickel(II) in molten chlorides, absorption spectra and nature of dilute solutions of alkali metals in fused alkali halides, solute species in molten fluorides, advances in the infrared spectroscopy of molten salts, Raman spectroscopy of fused salts and studies of halide-containing systems, investigation of fused salts by inelastic scattering of cold neutrons, transport processes and properties, electric conduction in fused salts, distribution of metals between molten fluoride and liquid metals, electrical double layer in molten chlorides, solutions of halogens in molten halides, electrode reactions in molten fluorides, voltammetric studies of chromium(II) in molten LiF–$BeF_2$–$ZrF_4$ at 500°C, and thermochemistry in fused nitrates. (M.C.G.)

**16506** TRICYCLOPENTADIENYLCURIUM. Laubereau, P. G.; Burns, John H. (Oak Ridge National Lab., Tenn). Inorg. Nucl. Chem. Lett.; 6: 59-63(Jan 1970).

A highly purified sample of curium dissolved in 0.05N HCl was used for the synthesis. Only data peculiar to the preparation of $Cm(C_5H_5)_3$ are reported since a detailed description of the general procedure has already been reported previously (Laubereau, P.; Burns, J. H.; submitted to Inorganic Chemistry (1969)) dealing with the preparation of $Bk(C_5H_5)_3$ and $Cf(C_5H_5)_3$. Identification of $Cm(C_5H_5)_3$ was by an x-ray method. The space group and unit-cell dimensions were determined by growing a single crystal. These data enabled a powder pattern to be calculated from which it is apparent that the compounds are isomorphous. The optical properties are consistent with a $Cm^{3+}$ complex. It was deduced that the overall properties of $Cm(C_5H_5)_3$ resemble those that are known for other tricyclopentadienyls of the actinides and lanthanides. (UK)

**16507** COMPLEXES OF DIISOPROPYL METHYLPHOSPHONATE WITH METAL SALTS CONTAINING COMPLEXING ANIONIC GROUPS. Karayannis, N. M.; Owens, C.; Pytlewski, L. L.; Labes, M. M. (Drexel Inst. of Tech., Philadelphia). J. Inorg. Nucl. Chem.; 32: 83-90(Jan 1970).

Although the synthesis of complexes of diisopropyl methylphosphonate (DIMP) with metal salts containing anions with coordinating ability presents severe difficulties in most cases, a number of complexes were isolated and characterized by means of spectral, magnetic and conductance studies. These include nitrato and thiocyanato complexes of the types $[UO_2(DIMP)_2(O_2NO)_2]$ and $[M(DIMP)_4(NCS)_2]$ (M = Mg,Ni), and quaternary crystalline complexes obtained from systems of the type $MgCl_2 \cdot MCl_2 \cdot DIMP \cdot H_2O$ (M = Mn, Co, Ni, Cu, Zn). No stable or sufficiently pure complexes of DIMP with 3d or alkaline earth metal halides could be obtained. By utilization of equimolar amounts of anhydrous $MgCl_2$ and $MCl_2$ hydrate in the presence of DIMP, chloride ions were transferred from Mg(II) to M(II) and the chlorometallate anion was stabilized by the large complex cation which consists of Mg(II) coordinated to DIMP and water molecules and, in some cases, chloride ions. The complexes synthesized in this way were assigned the structures $[Mg(DIMP)_4(H_2O)_2][MCl_4]$ (M = Mn, Co, Zn), $[MgCl(DIMP)_3(H_2O)_2]$ $[NiCl_3(DIMP)]$ and $[MgCl(DIMP)(H_2O)_4]$ $[CuCl_3]$ DIMP. The latter complex is one of the few examples of a stable compound of the trichlorocuprate(II) anion. The structure of this compound involves one free DIMP molecule enclosed in cavities in the lattice. (auth) (UK)

**16508** THE IONIZATION POTENTIALS OF METHYL CYANIDE AND METHYL ACETYLENE BY PHOTOELECTRON SPECTROSCOPY AND SEMI-RIGOROUS LCAO SCF CALCULATIONS. Frost, D. C.; Herring, F. G.; McDowell, C. A.; Stenhouse, I. A. (Univ. of British Columbia, Vancouver). Chem. Phys. Lett.; 4: 533-6(15 Jan 1970).

The photoelectron spectra of methyl cyanide, methyl cyanide-$d_3$, and methyl acetylene were measured using the 584 Å helium resonance line as a light source. On the basis of CNDO/2 and INDO calculations the ionization potentials determined are assigned to ionizing processes from the various orbitals in these molecules. (auth)

**16509** ADSORPTION OF THORIUM AND ITS TTA-COMPLEXES FROM AQUEOUS SOLUTIONS. Edroth, Bo (Chalmers Univ. of Tech., Goteborg). Acta Chem. Scand.; 23: 2636-40 (1969).

The adsorption of trace concentrations of thorium on glass is independent of acidity up to pH 1, but increases thereafter to a maximum at pH 4.2. The thorium thenoyltrifluoroacetone complex is similarly adsorbed, but two maxima are observed, at pH 3.2 and 7.0. Adsorption on other materials such as stainless steel, gold, platinum, polypropylene, polyethylene, and teflon was also studied. Particularly high adsorption was found for the Th complex on teflon. (auth)

**16510** PREPARATION OF ACTINIDE BROMIDES AND BROMO-COMPLEXES BY USE OF LIQUID BORON TRIBROMIDE OR LIQUID BROMINE. Brown, D.; Hill, J.; Rickard, C. E. F. (Atomic Energy Research Establishment, Harwell, Eng.). J. Chem. Soc., A; No. 3, 476-80(1970).

New preparative methods are described for protactinium pentabromide, neptunium tetrabromide, hexabromoprotactinates(V), and hexabromouranates(V). New uranium pentabromide–phosphine oxide complexes of the type $UBr_5L$ (L = triphenylphosphine oxide or hexamethylphosphoramide) and the actinide tetrabromide–methyl cyanide adducts $NpBr_4$,MeCN and PuBr4, 4MeCN were also prepared. Some chemical properties, ir and visible spectral studies, and x-ray powder diffraction results are reported for these compounds. (auth) (UK)

**16511** STUDIES ON CUBIC MAGNESIUM URANATE, $Mg_yU_{1-y}O_{2+x}$. I. PHASE RELATIONS AND CRYSTAL CHEMISTRY. Fujino, Takeo; Naito, Keiji (Japan Atomic Energy Research Inst., Ibaraki). J. Inorg. Nucl. Chem.; 32: 627-36(Feb 1970).

Cubic magnesium uranate, $Mg_yU_{1-y}O_{2+x}$, was prepared by heating mixtures of $MgUO_4$, $MgU_3O_{10}$ and $UO_3$, with Mg/U ratios ranging from 0.025 to 0.05, in a stream of helium. The cubic region and the values of x and y in $Mg_yU_{1-y}O_{2+x}$ were studied under various reaction conditions. Density measurements of this compound gave strong support to a substitutional structure. The variation of lattice constant with composition was observed to follow a linear equation $a_0 = 5.4704 - 0.1170x - 0.5677y$. Equilibrium oxygen pressure was found to increase with magnesium concentration. The results obtained by modifying the equation to express partial molar entropy of oxygen given by Aronson and Clayton (J. Chem. Phys. 32: 749(1960)) are given. (auth) (UK)

**16512** KINETICS OF ISOTOPIC EXCHANGE BETWEEN ACETYLACETONE-$^{14}$C AND BISACETYLACETONATOPALLADIUM(II) IN ORGANIC SOLVENTS. Saito, Kazuo; Takahashi, Michihiko (Tohoku Univ., Sendai). Bull. Chem. Soc. Jap.; 42: 3462-6(Dec 1969).

Bisacetylacetonatopalladium(II) [Pd $acac_2$] was precipitated crystalline free from excessive acetylacetone (Hacac) by adding the reaction mixture in anisole, benzene, or 1,2-dichloroethane to chilled petroleum ether. Its specific counting rate was measured by liquid scintillation technique. The isotopic exchange rate is measurable at 40 to 80°C and the kinetics is expressed by the ordinary two term formula, Rate = [Pd $acac_2$]($k_1 + k_2$[Hacac]). The second term corresponds to the reagent path, in which the acetylacetone molecule rather than acetylacetonate anion acts as nucleophilic reagent. The first term seems to express a dissociation mechanism rather than the solvent path; the break of Pd–O bond without the aid of nucleophilic attack by the solvent molecule is responsible for determining the exchange rate. The exchange reaction is accelerated by acids, and the acid-catalyzed reaction path operates independent of the reagent path to give the following kinetic formula: Rate = [complex]($k_1 + k_2$[Hacac] + $k_3$[acid]). (auth)

**16513** SOLVENT EFFECT IN THE BASE-CATALYZED HYDROGEN ISOTOPIC EXCHANGE REACTION OF α-DEUTERIODIPHENYLTHIOACETAL. Minamida, Isao; Uneyama, Kenju; Tagaki, Waichiro; Oae, Shigeru (Osaka City Univ.). Bull. Chem. Soc. Jap.; 42: 3609-10(Dec 1969).

The H–D exchange reactions of α-deuterio-1,1-bis(phenylthio)ethane and α-deuterio-1,1-bis(ethylthio)ethane were studied in MeOH–MeONa, EtOH–EtONa, t-BUOH–t-BuOK, and t-BuOH–DMSO-t-BuOK systems in order to obtain information on the solvent effect and to compare the carbanion stabilizing effect of the phenylthio group with that of the ethylthio group. The kinetics

of the exchange were followed by measuring the intensity of the stretching of the C–D bond by means of ir spectroscopy. The rate of base-catalyzed exchange increased with increasing base strength, and the addition of DMSO enhanced the rate markedly. All results are tabulated. (B.L.M.)

**16514** PREPARATION OF CYCLIC PHOSPHATES OF URANIUM(VI). Kamo, Mutsukazu; Ohashi, Shigeru (Kyushu Univ., Fukuoka). Bull. Chem. Soc. Jap.; 42: 3616(Dec 1969).

Disodium uranyl tetrametaphosphate trihydrate was prepared by precipitation from an ethanol–water solution of sodium tetrametaphosphate and uranyl nitrate. The preparation is described in some detail. Analytical results for the analysis of the product are presented. (B.L.M.)

**16515** PHYSICAL AND CHEMICAL ASPECTS OF ADSORBENTS AND CATALYSTS. Linden, B. G. (ed.). London; Academic Press (1970). 674p. 150s.

This book covers most of the recent research on the physics and chemistry of a number of adsorbents and catalysts. The fourteen chapters are contributed by separate authors, one of which is in scope. A separate abstract was prepared for this chapter. (UK)

*For an abstract of one chapter see: 16516.*

**16516** HYDROLYTIC PHENOMENA IN U(VI) PRECIPITATION. Hermans, M. E. A. Chapter 8 of Physical and Chemical Aspects of Adsorbents and Catalysts. /Linden, B. G. (ed.). London; Academic Press (1970).

The studies reported are mainly of a chemical and physicochemical character and were all carried out to develop new processes for the production of rather specific nuclear fuels. The work is thus of interest in the ceramic field. A correlation was made between the different ways of hydrolysis with the properties of the final products. The sections of the chapter are entitled: the hydrolysis of uranyl ions, the application of hydrolytic processes for solids formation, and texture and thermal reactivity of precipitates and gels. (UK)

**16517** SURVEY OF PROGRESS IN CHEMISTRY. VOLUME 5. Scott, Arthur F. (ed.). New York; Academic Press Inc. (1969). 259p. $11.50.

Topics covered include: hard and soft acids and bases, olefin-forming elimination reactions, chemical information from microwave spectroscopy, the hydrated electron, and liquid scintillation counting. Separate abstracts were prepared for the last two papers. (M.C.G.)

*For abstracts of individual papers see: 16584 and 16852.*

**16518** ALKENESULFONIC ACIDS: PMR SPECTRA AND RATES OF BASE- AND ACID-CATALYSED DOUBLE-BOND ISOMERIZATION AND HYDROGEN–DEUTERIUM EXCHANGE REACTIONS. Brouwer, D. M.; Van Doorn, J. A. (Koninklijke/-Shell-Laboratorium, Amsterdam). Rec. Trav. Chim.; 88: 1041-57(Sep 1969).

The acid- and base-catalyzed double-bond isomerization and H–D exchange as well as the PMR spectra of some simple alkenesulfonic acids and related hydroxyalkanesulfonic acids were studied. The compound described in the literature as 2-methylpropene-1, 3-disulfonic acid (I) was found to be 2-methylenepropane-1, 3-disulfonic acid (II). Interconversion of I and II and of the 1- and 2-propene-1-sulfonic acids can be effected at 100°C in 1N NaOH as well as concentrated $H_2SO_4$. The equilibration of 2-propene-1-sulfonic acid and the hydrogen sulfate of 2-propanol-1-sulfonic acid in $H_2SO_4$ is much faster than the equilibration of these 2 compounds with 1-propene-1-sulfonic acid and is thought to involve intramolecular catalysis. Double-bond isomerization of 2-methyl-2-propene-1-sulfonic acid can only be effected under alkaline conditions since this compound reacts rapidly with $H_2SO_4$ to give eventually the disulfonic acids. Equilibrium constants for isomeric $\alpha$, $\beta$- and $\beta,\gamma$-unsaturated sulfonic acids are reported. The base-catalysed isomerizations are much slower than the H–D exchange of the $\alpha$-hydrogens; the rate of acid-catalysed exchange of both types of hydrogens in II is about the same as that of the double-bond migration. (BBB)

**16519** HYDROLYSIS OF URANIUM CARBONITRIDES. Sugihara, Sunao; Imoto, Shosuke (Osaka Univ.). J. Nucl. Sci. Technol. (Tokyo); 7: 67-71(Feb 1970).

The behavior in hydrolysis of uranium monocarbonitrides ($UC_{1-x}N_x$) of various compositions has been studied and compared with the hydrolysis of UN and UC. The products of the hydrolysis were found to be $H_2$, $CH_4$, $C_2H_6$, $C_3H_8$, $NH_3$, $CH_3NH_2$, $C_2H_5NH_2$, and $C_2H_7NH_2$, and did not vary qualitatively with the composition (C/N), while quantitatively their relative amounts, and also the temperature of formation were found to be markedly affected by the composition. The more carbon-rich compounds tended to be easily hydrolyzed below 100°C, as in the case of UC, while the amenity to hydrolysis was found significantly weaker with the nitrogen-rich compounds, as with UN. The hydrolysis of carbonitrides is characterized by the formation of amines, which were found particularly abundant in the case of $UC_{0.53}N_{0.47}$ (C : N ≈ 1 : 1). To elucidate the mechanism of the reaction under study, a mechanically mixed specimen of UN and UC was hydrolyzed. No amines were observed to be generated in this case. This finding was considered suggestive of two plausible mechanisms, namely, mutual interaction between free radicals located within short distances of each other, and the hydrogenation of skeletons such as C–C–N. (auth)

**16520** ROLE OF URANIA AND ALUMINA AS SUPPORTS IN THE STREAM REFORMING OF n-BUTANE AT PRESSURE OVER NICKEL-CONTAINING CATALYSTS. Bhatta, K. S. M.; Dixon, G. M. (Gas Council London Research Station, London). Ind. Eng. Chem., Prod. Res. Develop.; 8: 324-31(Aug 1969).

The effect of introduction of U into the catalyst, usually Ni, used for the steam reforming of hydrocarbons was studied. Coke formation on the active sites of the catalyst was reduced by the introduction of U to the catalyst formulation. Kinetic data implied that the water is preferentially adsorbed on the active surface of the nickel–urania catalyst, whereas in the case of a nickel–alumina catalyst the active surface is covered with adsorbed hydrocarbons. One of the roles of the support may be to supply oxygenated species, resulting from the adsorption of water, to the surface of the metal. If the role of the support is to supply oxygenated species to the surface of the nickel, the addition of K to the catalyst not only prevents coke buildup on the support but also keeps the surface free for the adsorption of water. Since the addition of K to both catalysts has no appreciable effect on the decline in catalytic activity, it is assumed that the formation of coke from butane in the presence of steam is a slow process over urania and alumina. (BBB)

**16521** FORMATION AND PROPERTIES OF URANIUM GLASSES. Chakrabarty, M. R. (Ontario Research Foundation, Toronto). Amer. Ceram. Soc. Bull.; 48: 1076-8(Nov 1969).

The region of glass formation in the system $UO_2$–$Na_2O$–$SiO_2$ was established, and glasses containing up to about 50 wt % $UO_2$ were prepared. It was found that $UO_2$ is highly soluble in glasses having a molar ratio of $Na_2O : SiO_2$ between 1 : 2 and 1 : 3. Refractive indices and densities of the glasses were determined. Complete oxidation of $UO_2$ in air may result in the formation of either $UO_3$ or $U_3O_8$. Molar refractivities were calculated in 2 ways, assuming complete oxidation of $UO_2$ to $U_3O_8$ in the first, and to $UO_3$ in the second. Only in the first case did the plot of molar refractivity vs moles of uranium oxide result in a straight line. (BBB)

**16522** CHEMISTRY OF URANIUM(V). Selbin, Joel (Louisiana State Univ., Baton Rouge); Ortego, J. D. Chem. Rev.; 69: 657-71(Oct 1969).

This review points out that the literature on the chemistry of U(V) is meager when compared to the voluminous data collected for the other oxidation states of U. This paucity of information may be related to the strong tendency of U(V) to disproportionate to U(IV) and U(VI), and the great ease and rapidity of oxidation of U(V) to U(VI). The extreme sensitivity of U(V) compounds to atmospheric oxygen and even trace amounts of water vapor requires very rigid experimental controls in their study. The topics considered include the compounds of U(V), i.e., halogen compounds and halo complexes, addition compounds of halides, alkoxides, halide alkoxides, and related compounds, and oxides and oxo compounds; magnetic susceptibilities and EPR studies; and spectral studies, i.e., vibrational spectra, electronic and vibronic spectra, and assignment of bands. Most of the compounds of quinquivalent U may be considered to contain the covalently bound U(V) species, the next most prevalent species being the oxo anions, $UO_3^-$, $UO_4^{3-}$, and $U_2O_5^{2-}$ (and perhaps $UO_4^{4-}$ and $U_2O_6^{4-}$), which are followed in abundance and stability by compounds of the oxo cation species $UO_2^+$ and $UO^{3+}$. Knowledge of these latter 2 species is extremely limited. The syntheses and stabilities of most of the known U(V) compounds are briefly discussed. The compounds are listed in tables, along with their colors and melting or boiling points. (BBB)

**16523** BEHAVIOUR OF URANYL ION IN NITRIC ACID SOLUTIONS WITH AMMONIUM MOLYBDOPHOSPHATE. Ganzerli Valentini, M. T.; Maxia, V.; Rollier, M. A.; Barbaro Forleo, M. (Univ., Pavia, Italy). J. Inorg. Nucl. Chem.; 32: 671-9(Feb 1970).

The behaviour of uranyl ion sorbed on ammonium 12-molybdophosphate in nitric and sulphuric acid solutions was studied under static conditions. The experimental results showed that the exchanged species is the hydroxouranyl ion, $UO_2OH^+$, and that sorp-

tion takes place at low acidity. Functional relations were established describing $UO_2OH^+$ sorption on AMP as a function of the concentrations of nitric and sulphuric acids, ammonium nitrate, and uranium in solution. (auth) (UK)

**16524** DIFFUSION OF DISSOLVED HYDROGEN AND DEUTERIUM IN LIQUID AMMONIA. Haul, R.; Puttbach, E. (Technische Univ., Hanover). Z. Naturforsch.; 24a: 1914-22 (Dec 1969). (In German).

Diffusion coefficients of $H_2$ and $D_2$ in liquid $NH_3$ were determined from rates of solution at constant partial pressure of the gases (9 atm) in the range −60 to +10°C. $D_0(H_2) = 9.4 \pm 0.4$; $D_0(D_2) = 7.4 \pm 0.4$ cm²/sec; $\Delta E(H_2) = 2090 \pm 30$; $\Delta E(D_2) = 2030 \pm 30$ cal/mole. The mechanism of diffusion and the isotope effects are discussed on the basis of the structure of liquid $NH_3$. (auth)

**16525** ORGANOMETALLIC COMPOUNDS OF BIVALENT YTTERBIUM. Evans, D. F.; Fazakerley, G. V.; Phillips, R. F. (Imperial Coll. of Science and Tech., London). J. Chem. Soc., D; No. 4, 244(18 Feb 1970).

Ytterbium metal reacts with alkyl and aryl iodides in tetrahydrofuran at low temperatures to give solutions of $RYb^{II}I$, which undergo typical Grignard-type reactions. (auth) (UK)

**16526** SOLVOLYSIS OF ORGANIC PHOSPHATES. II. PYRIDYLMETHYL PHOSPHATES AS EFFECTED BY THE PRESENCE OF POLYVALENT METAL IONS. Murakami, Yukito; Takagi, Makoto (Kyushu Univ., Fukuoka). Bull. Chem. Soc. Jap.; 42: 3478-83(Dec 1969).

Influence of polyvalent metal ions on the hydrolysis of 2-, 3- and 4-pyridylmethyl phosphates was investigated at $\mu = 0.10$ in a lower pH range. The thorium ion accelerated the hydrolysis rate of all the phosphates to a remarkable extent as investigated at 40, 70, and 90°C. The primary participation of the phosphate moiety of each pyridylmethyl phosphate in the interaction with thorium(IV) was considered to be the main cause of this catalysis. Thus, the thorium catalysis was mechanistically distinguished from the copper catalysis, which was clarified previously. In addition, the vanadyl ion also demonstrated positive catalytic effect. On the other hand, iron(III) and aluminum(III) retarded the hydrolysis rate. This was ascribed to the reduced fraction of the active monoionic species as a result of metal-complex formation with the phosphates in the course of hydrolysis. (auth)

**16527** PREPARATION, CRYSTALLOGRAPHIC, AND INFRARED PROPERTIES OF SOME ACTINIDE TETRAHALIDE–PHOSPHINE OXIDE COMPLEXES. Brown, D.; Hill, J.; Rickard, C. E. F. (Atomic Energy Research Establishment, Harwell, Eng.). J. Chem. Soc., A; No. 3, 497-501(1970).

Protactinium, neptunium, and plutonium tetrahalide–phosphine oxide complexes of the type $MX_4 2L$ [M = Pa, Np, and Pu; X = Cl and Br; L = triphenylphosphine oxide ($Ph_3PO$) and hexamethylphosphoric triamide [$(NMe_2)_3PO$)] were prepared by reactions in nonaqueous solvents. Thorium tetrabromide forms a 1:3 complex with triphenylphosphine oxide. Some chemical properties and x-ray powder diffraction results are reported, together with ir spectral results (4000–33 cm$^{-1}$) for these and some previously known uranium tetrahalide–phosphine oxide complexes. The assignment of metal–oxygen and metal–halogen stretching vibrations is discussed. (auth) (UK)

**16528** A SPECTROPHOTOMETRIC STUDY OF FERRIC AND URANYL CHELATES OF SOME 2-ACYLINDANE-1,3-DIONES. Zacharova-Kalavska, D.; Perjessy, A.; Zelensky, I. (Komensky Univ., Bratislava). Collect. Czech. Chem. Commun.; 35: 225-32 (Jan 1970).

Iron(III) and uranyl chelates of 2-acetyl-, 2-propionyl-, and 2-benzoylindane-1,3-dione (in proportions Fe: 3 ligands and $UO_2$: 2 ligands) were isolated in solid form. On the basis of electron spectra in the region of 240 to 360 nm and infrared spectra at 1400 to 1800 cm$^{-1}$, the 2-acylindane-1,3-diones were found to form, with $Fe^{III}$ and $UO_2^{2+}$ ions, cyclic chelates with delocalized π-bonds analogous to metal chelates of acetylacetone. Absorption maxima in these regions were assigned to $\pi \rightarrow \pi^*$ and $n \rightarrow \pi^*$ transitions, or alternatively, to valence vibrations of C=O, C=C, and aromatic ring groupings. It was established that the bands at 1770 cm$^{-1}$ of the 2-acylindan-1,3-diones were not ascribable to $\nu_{C=0}$ of a free triketo moiety, and that in solid phase as well as in solutions in aprotic solvents, these compounds exist exclusively in an enolic form stabilized by a strong intramolecular hydrogen bridge. (auth)

**16529** DISTRIBUTION OF THENOYLTRIFLUOROACETONE AND ITS URANIUM(VI) CHELATE IN OXONIUM SOLVENT SYSTEMS. Suzuki, Nobuo; Akiba, Kenichi (Tohoku Univ., Sendai). Res. Rep. Lab. Nucl. Sci., Tohoku Univ.; 2: No. 1, 134-7(Jun 1969). (In Japanese).

The role of oxonium solvents as medium and electron donating agent for the $UO_2(II)$–TTA complex was investigated. The distribution ratio, $D_M$, increases remarkably in the case of oxonium solvents, because of the coordination of oxonium solvents to the chelate. The plot of log $D_M$ vs. log $[S]_{org}$ shows the straight line with a slope of 1, that indicates one solvent molecule coordinates to the chelate. In the case of solvents containing electron withdrawal atom or group, such as bis(2-chloroethyl)ether, the plots show negative deviation from the straight line. These results imply that even when some interaction occurs between solvent molecule and chelate, the regularity of solvent effect as a whole can be expected. The plot of log $D_M(UO_2A_2)$ vs. log $D_M(ZnA_2)$ indicates a straight line with a slope of 1 and indicates that the mechanism of coordination of solvents is the same in these two chelates. (NSA of Japan)

**16530** THE HYDROGEN–DEUTERIUM EXCHANGE OF BENZENE AT A FUEL CELL ELECTRODE. Barger, H. J. Jr.; Coleman, A. J. (Army Mobility Equipment Research and Development Center, Fort Belvoir, Va.). J. Phys. Chem.; 74: 880-6(19 Feb 1970).

The hydrogen–deuterium exchange of benzene at a fuel cell electrode was studied at 0.30 V. After electrochemical pretreatment, the electrode was potentiostatically held at 0.30 V as benzene passed over the electrode surface. The amount of exchange increased rapidly for 1 to 2 min then abruptly diminished. The percentage of the various deuteriobenzenes ranging from $C_6H_5D$ to $C_6D_6$ suggests at least two types of exchange reactions, both of which occur concurrently. (auth)

**16531** ISOTOPIC EXCHANGE REACTIONS IN NITROGEN OXIDES. Sharma, H. D. (Univ. of Waterloo, Ont.); Jervis, R. E.; Wong, K. Y. J. Phys. Chem.; 74: 923-33(19 Feb 1970).

The kinetics of the oxygen self-exchange in $N^{16}O_2 + N^{18}O_2 \rightleftharpoons 2N^{16}O^{18}O$ reaction was studied in a fast-flow gas-phase tubular reactor in conjunction with a time-of-flight mass spectrometer. The reaction is second order and has a rate constant of $3.0 \pm 0.1 \times 10^8$ l mol$^{-1}$ sec$^{-1}$ at 25°C. The rate constant has no measurable temperature dependence between 25 and 82°C. The rate constant for oxygen atom exchange in $^{14}NO + {}^{15}NO_2 \rightleftharpoons N_2O_3$ reaction is $4.9 \pm 0.8 \times 10^7$ l mol$^{-1}$ sec$^{-1}$ at room temperature. The kinetics of exchange in the $NO_2$–$NO_2$ system indicates that a cyclic structure O–N<O–O>N–O exists either in the transition state or as an intermediate. Similarly the exchange in the NO–$NO_2$ system takes place through O–N<O–O>N–O. Other exchange studies in the systems $NO_2$–$^{18}O_2$ and NO–$NO_2$–$^{18}O_2$ indicate that the rapid self-exchange in the $N^{16}O_2$–$N^{18}O_2$ and $^{14}NO$–$^{15}NO_2$ systems does not take place through any dissociative mechanism. (auth)

**16532** NMR EVIDENCE FOR ELECTRON SPIN DELOCALIZATION IN ORGANOMETALLIC U(IV)-COMPOUNDS. Von Ammon, R. (Gesellschaft fuer Kernforschung, Karlsruhe, Ger.); Kanellakopulos, B.; Fischer, R. D. Chem. Phys. Lett.; 4: 553-7(15 Jan 1970).

The temperature dependence of the PMR shifts of $U(C_5H_5)_4$ and $(C_5H_5)_3UBH_4$ was studied between 165 and 428°K. Both for the ring protons of $U(C_5H_5)_4$ and for the borohydride protons of $(C_5H_5)_3UBH_4$ a remarkably large indirect electron spin transfer is indicated. The particularly large average spin transfer to the $BH_4$ group is best explained by the presence of more than only one U–H–B bridging position. (auth)

**16533** DEUTERIUM ISOTOPE EFFECTS AND THE DISSOCIATION OF DEUTERIOPHOSPHORIC ACID FROM 5 TO 50°. Paabo, Maya; Bates, Roger G. (National Bureau of Standards, Washington, D. C.). J. Phys. Chem.; 74: 706-10(19 Feb 1970).

The first dissociation constant of deuteriophosphoric acid in deuterium oxide was determined over the temperature range 5 to 50° from emf measurements of cells using deuterium gas electrodes and silver–silver chloride electrodes, with the following results: $pK_1 = 843.979/T - 4.5714 + 0.0139555T$, where T is the thermodynamic temperature. The changes of enthalpy, entropy, and heat capacity characterizing the dissociation process were derived from $pK_1$ and its temperature coefficient. By comparison of the results with similar data for protiophosphoric acid in water, the deuterium isotope effects on $pK_1$ and the thermodynamic functions were evaluated. The isotope effect $pK_1$ (in $D_2O$) − $pK_1$ (in $H_2O$) is 0.272 unit and almost unchanged over the temperature range studied. This value confirms a linear relationship between the isotope effect for inorganic acids and pK (in $H_2O$). (auth)

**16534** PROCEEDINGS OF THE SYMPOSIUM ON ELECTROCATALYSIS, EINDHOVEN, NETHERLANDS, 21–22 NOVEMBER 1968. Schuit, G. C. A.; Sparnaay, M. J.; Visscher, W. H. (eds.). Surface Sci.; 18: 1-180(Nov 1969). (CONF-681133).

Eleven papers presented at the conference are included. Topics include: heterogeneous transfer to aromatic hydrocarbon molecules, chemisorption and catalytic reactions of hydrogen at metal surfaces, electrocatalysis and the nature of the electrode, electrode kinetics and double layer structure, chemisorption and catalysis by nickel–copper alloys, correlation between catalytic activity and surface states, charge transfer processes at semiconductor–electrolyte interfaces, adsorption on semiconductors, influence of cesium adsorption on surface Fermi level position in gallium arsenide, electrocatalysis, and model calculations for adsorption on transition metals. A separate abstract was prepared for one paper. (M.C.G.)

*For an abstract of one paper see: 16535.*

**16535** CORRELATION BETWEEN THE CATALYTIC ACTIVITY OF METALS AND THE SURFACE STATES RESULTING FROM THE REACTION OF THE GASEOUS REACTANTS AND THE METAL. Frennet, A.; Lienard, G. (Institut Interuniversitaire des Sciences Nucleaires, Brussels). Surface Sci.; 18: 80-96(Nov 1969).

From Conference on Electrocatalysis, Eindhoven, Netherlands. See CONF-681133.

Several previous investigations are presented where the reaction between gaseous reactants and freshly prepared films is conducted under experimental conditions where isotopic exchange reaction between the same reactants proceeds. The surface of Mo and W films is entirely covered with chlorine atoms during the $H^{35}Cl-CH_3Cl$ exchange. The mechanism is decomposed in two "elementary exchanges": $H^{36}Cl + S\text{-}Cl \rightarrow S\text{-}^{36}Cl + HCl$ and $CH_3Cl + S\text{-}^{36}Cl \rightarrow S\text{-}Cl + CH_3{}^{36}Cl$. In the study of the $CH_4-D_2$ exchange, the metals are classified in three groups: (1) on Cu and Ag, no chemisorption occurs and no exchange is measurable; (2) on Mo, W, Ni, Ta, Re, the variation of the catalytic activity is related to the modifications of surface states with time; (3) on Rh, a quantitative relation is developed between the catalytic activity and the hydrocarbon surface content. The influence of the catalytic activity of chemisorbed radicals, which are not direct intermediates in the reaction, is pointed out. A model is presented describing the formation of the reaction products by a displacement step. In this model a catalytically active site includes the presence of chemisorption sites, hindered but not covered near a chemisorbed radical. (auth)

**16536** TRANSFER AND STORAGE OF ENERGY BY MOLECULES, VOLUME 1. ELECTRONIC ENERGY. Burnett, George M.; North, Alastair M. (eds.). A Multi-volume Treatise. New York; John Wiley and Sons, Inc. (1969). 247p. $11.95.

The following topics are covered in 4 chapters: electronic and vibrational energy transfer in gas-phase systems; thermal population of excited electronic states–excitation and emission in shock waves; chemistry of electronically excited states of organic molecules; and energy transfer in radiation chemistry. A separate abstract was prepared for one chapter. (M.C.G.)

*For an abstract of one chapter see: 16608.*

**16537** FURTHER OBSERVATIONS ON THE REGULARITIES ASSOCIATED WITH THE FORMATION OF LANTHANIDE AND ACTINIDE COMPLEXES. Siekierski, S. (Inst. of Nuclear Research, Warsaw). J. Inorg. Nucl. Chem.; 32: 519-29(Feb 1970).

On the basis of ample experimental evidence it has been established that most of the complexes of the following pairs of lanthanides Ce, Pr; Sm, Eu; Tb, Dy; Tm, Yb, and actinides Bk, Cf, show extra stability in comparison to that resulting from linear interpolation between the following elements: La–Nd, Pm–Gd, Gd–Ho, Er–Lu and Cm–Es. The existence of analogous changes with Z in the radii of the lanthanides has been observed. The regularities in the separation factors of adjacent lanthanides and actinides are discussed. (auth) (UK)

**16538** LANTHANIDE COMPLEXES OF TRIMETHYL PHOSPHATE AND METHYL ETHYLENE PHOSPHATE. Graham, Patricia; Joesten, Melvin (Vanderbilt Univ., Nashville). J. Inorg. Nucl. Chem.; 32: 531-5(Feb 1970).

Complexes of trimethyl phosphate (TMP) and methyl ethylene phosphate (MEP) with selected lanthanide(III) perchlorates and uranyl perchlorate were isolated and characterized. The number of phosphate molecules coordinated to the lanthanide ions are five to seven for TMP and eight for MEP. Ir and conductance data provide evidence for coordinated perchlorate in the TMP complexes. Complexes of uranyl perchlorate contain five molecules of organic phosphate per uranyl ion. (auth) (UK)

**16539** REACTIONS BETWEEN 8-AMINOQUINOLINE AND METAL IONS AND VOLUMETRIC DETERMINATION OF 8-AMINOQUINOLINE. Yamamoto, Katsumi; Noda, Yasutoshi (Ibaraki Univ., Mito, Japan). Jap. Anal.; 19: 112-14(Jan 1970). (In Japanese).

The reactions of 8-aminoquinoline with 35 different metal ions were compared in acetic acid and ammonia and sodium hydroxide solutions. Cu(II), Zn(II), Fe(II), Fe(III), Ni(II), Co(II), Pd(II), Mn(II), V(V), W(VI), Ag(I), Ce(IV), Pt(IV), Sn(II) and Tl(III) precipitated immediately or after standing overnight. Pd(II) and W(VI) were precipitated even in 0.1 N HCl solution. A bromimetric method for 8-aminoquinoline is also proposed. (auth)

**16540** COMPLEX FORMATION IN AQUEOUS SOLUTION BETWEEN URANYL ION AND SOME SATURATED DICARBOXYLIC ACIDS. Vanni, Adriano; Ostacoli, Giorgio; Roletto, Ezio (Univ., Turin). Ann. Chim. (Rome); 59: 847-59(1969). (In Italian).

A potentiometric study of complex formation between malonic, methyl-, dimethyl- and diethyl-malonic, succinic, glutaric, adipic, and pimelic acids and the uranyl ion at ionic strength of 0.5 M ($KNO_3$) and $t = 25 \pm 0.5°C$ is reported. The values of the formation constants of the complexes MA and $MA_2$ ($M = UO_2^{++}$) are reported for the malonic and methyl-, dimethyl- and diethylmalonic acids. For the succinic, glutaric, adipic, and pimelic acids the values of the formation constants of the complexes MHA and MA were also determined. The data referring to the equilibria between malonic and metylmalonic acid and uranyl ion indicate the presence of MA(OH) complexes at $pH \geq 3$. Relationships among the formation constants evaluated are discussed. (auth)

**16541** LIGAND SUBSTITUTION CATALYSIS VIA HARD ACID–HARD BASE INTERACTION. Clark, Howell R.; Jones, Mark M. (Vanderbilt Univ., Nashville). J. Amer. Chem. Soc.; 92: 816-22(25 Feb 1970).

Spectrophotometric and potentiometric methods were used to obtain quantitative rate data, which show that certain cations accelerate the hydrolytic displacement of fluoride from a variety of anionic fluoro complexes. Typical hard acids, such as Be(II), Al(III), Zr(IV), and Th(IV), catalyze the hydrolysis of $AsF_5(OH)^-$, $PF_6^-$, $BF_4^-$, and $AsF_6^-$. The extent of catalysis varies with the catalyst: total fluoride ratio, the pH of the hydrolysis media, and the stability of the catalyst ion-fluoro complex. Catalyzed hydrolyses are first order in substrate only when the ratio of catalyst to substrate is large. Direct interaction between bound fluoride and the catalyst ion rather than promotion of an acid catalyzed reaction is shown by the extensive hydrolysis of $PF_6^-$ and $AsF_6^-$ under conditions of acidity (pH 2) where the uncatalyzed hydrolysis has a half-life of several months. These results show that the hard and soft acid-base theory can be used to select catalysts for replacement of ligands by basing the selection on the hard or soft nature of the ligand to be replaced. (auth)

**16542** RATES AND ISOTOPE EFFECTS IN THE QUINONE OXIDATION OF LEUCO TRIPHENYLMETHANE DYES. Lewis, Edward S.; Perry, James M.; Grinstein, Reuben H. (Rice Univ., Houston, Tex.). J. Amer. Chem. Soc.; 92: 899-905(25 Feb 1970).

Rates and hydrogen isotope effects in the oxidation of some leuco dyes of the form of 4,4'-bisdimethylamino-n-X-triphenylmethane by quinones (mostly halogenated p-benzoquinones) were studied. For the case of the 4''-dimethylamino substituent (chloranil) the rates were studied as a function of temperature in acetonitrile and in methanol with both hydrogen and deuterium in the tertiary position. In acetonitrile the rate constant of the hydrogen compound is given by $k_H = 1.2 \times 10^5 \exp(-8150/RT)$ and the isotope effect by $k_H/k_D = 0.041 \exp(3360/RT)$. The isotope effects were less precise in methanol, and were somewhat smaller, but the $A_H/A_D$ factor was still less than unity. Rates and isotope effects are presented for several other quinones and leuco dyes and electronic and perhaps small steric effects were observed. The oxidation with 2,3-dichloro-5,6-dicyanoquinone was too fast to measure, but competitive measurements showed that the reaction had about the same $\rho$ as with chloranil but a smaller isotope effect. The results are entirely consistent with tunneling in this hydride-transfer reaction. (auth)

**16543** DEPENDENCE OF THE PRIMARY ISOTOPE EFFECT ($k^H/k^D$) ON BASE STRENGTH FOR THE PRIMARY AMINE CATALYZED IONIZATION OF NITROETHANE. Dixon, J. Edward; Bruice, Thomas C. (Univ. of California, Santa Barbara). J. Amer. Chem. Soc.; 92: 905-9(25 Feb 1970).

Primary kinetic isotope effects ($k^H/k^D$) were determined in both water and 50% dioxane–water (v/v) for the primary amine catalyzed ionization of nitroethane and nitroethane-1-$d_2$. In water the $pK_a$ of nitroethane is 8.5 and the values of $k^H/k^D$ appear to be maximal for amines whose conjugate acids possess $pK_a$ values near 8.5 (i.e., near $\Delta pK_a = 0$). In the 50% dioxane–water solvent the $pK_a$ of nitroethane is 10.7 and it would appear as though the maximum in $k^H/k^D$, if any, must pertain to amines of $pK_a > 10$.

If it is concluded that these results are not fortuitous then it follows that transition state symmetry is dependent on ground-state basicity. Also, since the Brønsted plots for both $k^H$ and $k^D$ are linear it must be concluded that the primary kinetic isotope effects are a more sensitive probe of transition state than are Brønsted plots. (auth)

**16544** RATE-DETERMINING STEPS IN THE OXIDATION OF SUCCINATE CATALYZED BY SUCCINIC DEHYDROGENASE. Hollocher, Thomas C.; You, Kwan-sa; Conjalka, Mike (Brandeis Univ., Waltham, Mass.). J. Amer. Chem. Soc.; 92: 1032-5 (25 Feb 1970).

The magnitude of the kinetic isotope effect observed in the oxidation of tetradeuteriosuccinate depends on the concentration of oxidant and not on the concentration of succinate. Fumarate and dideuteriofumarate are identically effective as competitive inhibitors of succinic dehydrogenase against both succinate and tetradeuteriosuccinate. It was concluded that the isotope effect occurs at a step prior to the attack of oxidant, presumably on reduction of the enzyme by succinate and that this step is rate determining when the step involving attack by oxidant is not rate determining. (auth)

# Radiation and Nuclear Chemistry

*Refer also to abstracts 16485, 16791, 16926, 16991–16993, 16995, 18056, and 18367.*

**16545** (AECL-3477) CHEMISTRY AND MATERIALS DIVISION PROGRESS REPORT, JULY 1–SEPTEMBER 30, 1969. (Atomic Energy of Canada Ltd., Chalk River (Ontario). Chalk River Nuclear Labs.). 91p. (PR-CMa-10). Dep. CFSTI (U. S. Sales Only). AECL $2.00.

Developments are reported for studies in solid state, general chemistry, physical chemistry, and materials science. Also included are brief progress reports of research at University of Western Ontario on stress generated in oxide films during oxidation of Zr alloys and x-ray diffraction studies of oxidized samples (P.C.H.)

**16546** (BNL-13812) OZONE SYNTHESIS FOR WATER TREATMENT BY HIGH ENERGY RADIATION. Steinberg, Meyer; Beller, Morris (Brookhaven National Lab., Upton, N. Y.). Jul 1969. 36p. (CONF-691108-1). Dep. CFSTI.

From 62nd Annual Meeting on Waste Treatment Applications of Radiation Chemistry, Washington, D. C.

The use of ozone in tertiary treatment of secondary waste effluent is briefly reviewed. The high energy radiation synthesis and the electric discharge synthesis of ozone are compared. The results of basic radiation chemistry studies and tests with the Brookhaven Chemonuclear In-Pile Research Loop indicate that G-values for ozone production from oxygen in a high pressure production facility can range between 10 and 15. These energy yields are at least 2 to 3 times higher than are obtained by the electric discharge process. Isotopic radiation sources such as waste fission product $^{137}Cs$ can mainly be considered for treating drinking water or for smaller quantities of sewage effluent in the range of 10 Mgd. The fission fragment chemonuclear process has a distinct economic advantage over all other systems, including the electric discharge process, in the high capacity range, producing hundreds of tons of ozone per day, capable of treating waste effluent in the hundreds of Mgd to over a billion gallons per day sizes. Conceptual design and cost estimates of the chemonuclear process are presented. The chemonuclear process cost is half that for the electric discharge ozonizer cost at higher capacities. For a billion gallons per day sewage capacity, removal of 20 ppM COD (chemical oxygen demand) with chemonuclear ozone could be accomplished for 1.25¢/1000 gallons. There is thus a large incentive for further development of a fission fragment chemonuclear process for ozone production. (auth)

**16547** (BNL-14350) PREPARATION AND CHARACTERISTICS OF CONCRETE-POLYMER COMPOSITES. Steinberg, M.; Kukacka, L. E.; Colombo, P.; Manowitz, B. (Brookhaven National Lab., Upton, N. Y.). Jan 1970. 27p. (CONF-700201-1). Dep. CFSTI.

From 159th National American Chemical Society, Houston, Tex.

Preformed mortar and concrete can be fully impregnated with monomer and polymerized in situ by either radiation or thermal-catalytic techniques. The concrete–polymer has been found to have substantially improved structural properties and durability compared with those of conventional concrete. The improvement in the properties appears to be a function of the polymer loading. Maximum increases in strength are obtained by forming and curing the concrete, subsequently drying, evacuating, and soaking the concrete in monomer, and initiating polymerization by radiation. Increases in strength by as much as a factor of four over that of the control specimens have been obtained. Water permeability, water absorption, and chemical attack by distilled water, sulfate brines, and hydrochloric acid were reduced to negligible values compared with severe attack observed on the control specimens. The thermoplastic monomers methyl methacrylate, styrene, and chlorostyrene are of value for normal temperature applications. Cross-linked and thermosetting monomers such as 60% styrene–40% trimethylopropane trimethacrylate, diallyl phthalate, polyester–styrene, and epoxystyrene impregnated in concrete allow the maintenance of strength and durability properties up to temperatures of the order of 150°C. Radiation treated concrete–polymer displays strength properties that are from 12% to 38% higher than is thermal catalytically treated material. Concrete-polymer significantly increases the bond strength and flexural strength of steel-reinforced and fiber-reinforced concrete. There appears to be little difference between the effects of radiation and thermal treatment on the durability of concrete-polymers except that which can be attributed to polymer loading. A preliminary comparison between concrete–polymer and other materials of construction indicates reasonable economic potential for certain applications. (auth)

**16548** (RFP-1439) RADIOLYSIS OF DISOPROPYLAMINE AND DIISOPROPYLAMINE HYDROCHLORIDE. Kazanjian, Armen R. (Dow Chemical Co., Golden, Colo. Rocky Flats Div.). 25 Feb 1970. Contract AT(29-1)-1106. 3p. Dep. CFSTI.

A radiolytic investigation was made of diisopropylamine (DIA) and diisopropylamine hydrochloride (DIA·HCl). DIA is the stabilizer commonly used in trichloroethylene, a solvent used for cleaning plutonium. DIA·HCl is the hydrochloric acid salt of DIA that is formed in the stabilized solvent by radiative or thermal decomposition. This work was done to determine the potential corrosion to plutonium from the radiolytic decomposition of these two compounds. No attempt was made to compare the radiation stability of these compounds to the stability of other additives for solvents. Both compounds were gamma irradiated in air and under vacuum. The major radiolysis products are hydrogen and methane. Acetone and carbon monoxide are also produced in the presence of air. Hydrogen is the most abundant product with G values from 1 to 4 depending on the compound and conditions. Especially important from a corrosion standpoint was the fact that HCl was never detected as a product in DIA·HCl. It was concluded that the hydrogen yield from DIA-HCl may be corrosive toward plutonium because the low vapor pressure of DIA·HCl makes long exposures possible. (auth)

**16549** RADIATION CHEMISTRY OF HYDROCARBONS. PART 17. HEXANE–NO. Menger, Andre; Gaeumann, Tino (Eidgenoessische Technische Hochschule, Lausanne, Switzerland). Helv. Chim. Acta; 52: 2129-32(31 Oct 1969). (In German).

The influence of NO on the radiolysis of hexane at −70°C was studied. Irradiation was carried out with a $^{60}Co$ γ source at a dose rate of 0.5 Mrad/hr over the dose range 1 to 10 Mrad. The G values for the products are given. The bimolecular part of the hydrogen production is in opposition to $N_2O$ efficiently quenched by NO. This part involves nonthermal hydrogen atoms and has a G-value of about 1.4. All olefins are suppressed, probably in a secondary chain reaction with NO. The radical yield is drastically reduced by very low concentrations of NO, but by higher concentrations this decrease is slowed down. A reaction scheme proposed by Burrell explains these results. (BBB)

**16550** RADIATION CHEMISTRY OF HYDROCARBONS. PART 16. BENZENE–BROMOBENZENE. Siegrist, Renato; Gaeumann, Tino (Eidgenoessische Technische Hochschule, Lausanne, Switzerland). Helv. Chim. Acta; 52: 2119-28(31 Oct 1969). (In German).

The radiolysis of bromobenzene in benzene under the effect of $^{60}Co$ γ radiation at a dose rate of 0.5 Mrad/hr was studied. The decrease of concentration of bromobenzene and the formation of biphenyl and bromobiphenyl were determined. Bromobenzene is in competition with its own products for the reactive state of benzene or it can transfer its energy to its products. The rate of this transfer to decomposition is 74 l/mole. With the help of additives it was shown that they can act in 2 ways: first they compete with bromobenzene for an activated state of benzene in a reaction that does not depend on temperature. The nature of this activated state has not been determined. Secondly, they scavenge phenyl radicals that have been formed in about 70% of the decomposed bromobenzene molecules. This yield depends slightly on temperature. The relative reactivities compared to bromobenzene for the first case and to benzene in the second were determined as follows: naphthalene (0.6, 23); anthracene (5.8; 800); benzophenone (0.5, 17); cyclohexene (–; 20); $N_2O$ (0.018; –); NO (1.7; 250); $O_2$ (–; 3400). Naphtha-

cene in benzene is strongly decomposed in the presence of bromobenzene. but it also enhances the decomposition of the latter. (BBB)

**16551** RADIATION CHEMISTRY OF HYDROCARBONS. PART 15. ENERGY TRANSFER IN THE BENZENE-3-PHENYLCYCLOHEXA-1,4-DIENE SYSTEM. Zimmerli, Bernhard; Gaeumann, Tino (Eidgenoessische Technische Hochschule, Lausanne, Switzerland). Helv. Chim. Acta; 52: 1613-24 (22 Sep 1969). (In German).

Gas chromatographic studies were performed on radiolysis products in a study of energy transfer in a γ-irradiated aromatic scintillator solution. 3-Phenylcyclohexa-1,4-diene, which is a reaction product in benzene radiolysis, was decomposed when its solutions in benzene were γ irradiated. The main products were biphenyl (20%) and dihydrobenzene (10%). They showed that hydrogen from phenylcyclohexadiene is transferred to benzene. The high G-value for the disappearance was explained by energy-transfer from a high-lying state of benzene, formed with $g(B^*) \geq 2$, to the diene. From the concentration dependence in the range 0.015 to 0.25 mole/l, it was concluded that $\tau \cdot k_{tA}$ is 21 l/mole for phenylcyclohexadiene and 4 l/mole for cyclohexene, where $\tau$ is the lifetime of the excited state of benzene involved in the reaction and $k_{tA}$ is the rate constant for energy-transfer from this excited state to the acceptor. This rate constant was in the same order of magnitude for biphenyl, naphthalene, and cyclohexa-1,4-diene as accepted for phenylcyclohexadiene. The nature of the energy transfer from benzene to phenylcyclohexadiene is discussed. The possibilities of charge transfer or the lowest singlet or triplet state as excited states are ruled out. (BBB)

**16552** HIGHLY RADIATION-SENSITIVE TELOMERIZED POLYAMIDES. D'Alelio, Gaetano F. (to PPG Industries, Inc.). U. S. Patent 3,483,105. 9 Dec 1969. Filed 18 May 1966.

The preparation of highly radiation-sensitive telomerized diacrylyl polyamides is described in which the polyamides are treated by subjecting them to high-energy ionizing radiation so as to produce three-dimensional crosslinked, soluble infusible polymers at relatively low doses of radiation. The telomerized polyamides are linear and are derived from the condensation of a glycidyl acrylate with a linear condensation polymer of the unsaturated aliphatic, including cycloaliphatic, polycarboxylic acids with saturated or unsaturated diamines or amino alcohols. These telemerized polyamides have as end groups the highly radiation-sensitive acryloxy group having the formula

$$CH_2 = \overset{R''}{\underset{|}{C}}\text{-}COOHCH_2\overset{|}{C}HCH_2\text{-}$$
$$\qquad\qquad\qquad\qquad\quad OX$$

where R" is hydrogen or $CH_3$ and X represents hydrogen or an acyl group of the formula R"' CO where R"' is hydrogen or an aliphatic hydrocarbon radical of 1 to 18 carbon atoms. (B.L.M.)

**16553** HIGHLY RADIATION-SENSITIVE TELOMERIZED POLYAMIDES. D'Alelio, Gaetano F. (to PPG Industries, Inc.). U. S. Patent 3,483,104. 9 Dec 1969. Filed 18 May 1966.

The preparation of highly radiation-sensitive telomerized diacrylyl polyamides is described in which the polyamides are treated by subjecting them to a high-energy ionizing radiation so as to produce three-dimensional crosslinked, soluble infusible polymers at relatively low doses of radiation. The telomerized polyamides are linear and are derived from the condensation of unsaturated aliphatic, including cycloaliphatic, polycarboxylic acids with saturated or unsaturated aliphatic polyamines or amino alcohols, whose end groups are capped by the highly radiation-

$$\overset{R'}{\underset{|}{C}}\text{-}COA\text{-}$$

sensitive acrylyl group $CH_2 =$ in which R" is hydrogen or $CH_3$ and A is either O or NH. (B.L.M.)

**16554** RADIATION GRAFT COPOLYMERIZATION OF HYDROPHILIC MONOMERS ONTO POLYESTER FIBER. Okada, Norio (Japan Atomic Energy Research Inst., Osaka). Sekiyu To Sekiyu Kagaku; 13: No. 12, 74-83(Dec 1969). (In Japanese).

The radioinduced grafting of hydrophilic monomers on polyester fibers, such as polyamide or acrylic fibers, was investigated as a means of improving the low hygroscopicity and poor dyeability of these fibers. The graft-polymerization of 4-vinylpyridine, acrylic acid, and methacrylic acid onto amorphous polyester fibers, elongated polyester fibers, and onto polyester textiles are described. The properties of the graft-polymerized fibers and textiles are reported. The grafting of acrylic acid is treated in most detail with temperature effect and dirt removal properties being reported. (TSS)

**16555** SHAPED ARTICLES COMPRISING RADIATION STERILIZED PROPYLENE HOMO-POLYMERS AND COPOLYMERS. Kelley, Joseph Matthew; Marinaccio, Paul Joseph (to Rexall Drug and Chemical Co.). British Patent 1,178,739. 21 Jan 1970. Priority date 29 Jul 1966, United States.

An article composed of a propylene homopolymer or a propylene–alpha–olefin copolymer, which does not discolor when sterilized by γ irradiation, is described. The polymer or copolymer must have a crystalline content of at least 40%, preferably 60%, and the alpha-olefin in the copolymer must have from 4 to 18 C atoms. One % by weight of a dialkyl ester of thiodipropionic acid is added as an additional stabilizer. (B.L.M.)

**16556** METHOD FOR PREPARING PLASTICS IMPREGNATED WOOD. Miettinen, Jorma Kalervo; Autio, Timo; Stromberg, Juhani. British Patent 1,178,215. 21 Jan 1970. Priority date 23 Feb 1967, Finland.

Plastics-impregnated wood is prepared by impregnating whole wood (natural wood ground into fibers or dust or reconstituted from fibers or dust) having a moisture content of <10% by weight with liquid resin mixture comprising an unsaturated polyester and styrene and/or methyl methacrylate and curing the impregnated wood by irradiation with β or γ radiation or a combination of β or γ radiation with the action of a chemical catalyst and heat. (B.L.M.)

**16557** METHOD FOR POLYMERIZING ETHYLENE BY RADIATION. Kagiya, Tsutomu (to Japan Atomic Energy Research Inst.). Japanese Patent 1969-20989. 8 Sep 1969. Filed 25 Nov 1966.

Ethylene is polymerized by ionizing radiation in either tert-butyl alcohol or in the alcohol mixed with $H_2O$, liquid $CO_2$, or some organic solvent to prevent adhesion of the polymer to the walls of the reaction vessel. The ionizing radiation may be x, γ, or β radiation at a dose rate of $10^4$ to $10^6$ R/hr. The temperature at the time of irradiation may be 0 to 120°C, and the desired pressure is >100 atm. (NSA of Japan)

**16558** METHOD FOR POLYMERIZING ETHYLENE CONTAINING IMPURITY OXYGEN BY RADIATION. Kagiya, Tsutomu (to Japan Atomic Energy Research Inst.). Japanese Patent 1969-20754. 5 Sep 1969. Filed 30 Jun 1966.

Ethylene containing O as impurity can be polymerized efficiently by radiation; consequently the economical production of polyethylene in industry is possible, without the usual complex process to remove the oxygen. A low-grade aldehyde is added to ethylene containing O as impurity in concentrations of 20 ppM to 2%. The ionizing radiation may be x, γ, β, or α at a dose rate from 100 to $1 \times 10^7$ RAD/hr. (NSA of Japan)

**16559** METHOD FOR POLYMERIZING ETHYLENE IN TWO STEPS BY RADIATION USING CARBON DIOXIDE AS THE MEDIUM. Kagiya, Tsutomu (to Japan Atomic Energy Research Inst.). Japanese Patent 1969-20757. 5 Sep 1969. Filed 3 Aug 1966.

A two-step method for radioinduced polymerization of ethylene in the presence of $CO_2$ results in high G value, good efficiency of polymerization, no adhesion of product to reactor wall, and easy adjustment of reaction temperature. The ethylene–$CO_2$ was first irradiated at a high dose rate, $10^4$ to $10^6$ R/hr, at a temperature of <60°C to initiate the polymerization and then irradiated at 100 to 1000 R/hr at a temperature of 0 to 30°C. The radiation may be α, β, γ, or x radiation. (NSA of Japan)

**16560** METHOD FOR GRAFT–COPOLYMERIZING SILICONE ONTO FIBER. Yokoyana, Shikanosuke. Japanese Patent 1969-20275. 1 Sep 1969. Filed 18 Jul 1966.

Silicone can be efficiently graft polymerized onto fiber to yield a water-repellent product that is durable for washing. The fiber to be polymerized is first dyed by an ordinary process with a dye containing a metal in the form of a complex salt. The dyed fiber in the presence of silicone is irradiated with ionizing radiation at a relatively low dose. (NSA of Japan)

**16561** INVESTIGATIONS IN THE FIELD OF RADIATION-INDUCED SOLID STATE POLYMERIZATION. XXV. INFLUENCE OF A SECOND COMPONENT ON THE SOLID STATE POLYMERIZATION OF CETYL VINYL ETHER. Hardy, Gy.; Nyitrai, K.; Cser, F. (Research Inst. for Plastics, Budapest). Acta Chim. Acad. Sci. Hung.; 62: 253-62(1969).

The kinetics of solid state radioinduced polymerization were investigated in the binary systems cetyl vinyl ether–p benzoquinone and cetyl vinyl ether–dimethyl oxalate. It was found that the additives somewhat retard polymerization up to the eutectic composition, but at higher concentrations their effect remains unchanged. The solid state polymerization of cetyl vinyl ether occurs by cat-

ionic mechanism; this was confirmed by its solid state polymerization initiated with iodine vapor. (auth)

16562 GRAFT COPOLYMERIZATION OF ACRYLAMIDE ONTO $^{60}$Co γ-RAY PREIRRADIATED COTTON FABRICS IN AQUEOUS DIOXANE AND SOME TEXTILE PROPERTIES OF THE GRAFTED COTTON FABRICS. Ikeda, Tetsuo; Hamanaka, Mikiko (Kyoto Univ.). Sen'i Gakkaishi; 25: 447-54(Oct. 1969). (In Japanese).

Graft copolymerization of acrylamide onto the $^{60}$Co γ preirradiated cotton fabrics was investigated in various water–dioxane mixtures. The effects of the grafting mediums on the swelling behavior of the fabrics and degree of grafting or dimensional stability of the grafted fabrics (after extracted with hot water) was also studied. The degree of swelling of the cotton fabric in aqueous dioxane and 15% acrylamide aqueous dioxane solution where water contents are 20 to 80% shows higher values than those in water or dioxane alone. Absorbed monomer content in the cotton fabrics from the monomer solutions is almost constant and independent of the composition of the media and the degree of swelling of the fabrics. Degree of grafting or rate of copolymerization is nearly constant up to 50% dioxane content in the grafting media and then a significant decrease is observed, while the rate of catalyzed solution polymerization of acrylamide gradually decreases with increasing dioxane content in the polymerization media with the exception of the medium containing 10 to 30% water. Cotton fabrics grafted in the relatively higher swelling media showed less dimensional stability during grafting and hot water extraction, and the conditioned (dry) tensile strength of warp of the fabrics appeared to be slightly higher than those obtained in less swelling media. (NSA of Japan)

16563 PARTICULATE EXPANDED OLEFIN POLYMERS HAVING HIGH THERMAL STABILITY. (to Badische Anilin- and Soda-Fabrik AG). British Patent 1,178,890. 21 Jan 1970. Priority date 27 May 1966, Germany.

A process is described for the production of expanded particulate ethylene or propylene polymers having a particle diameter of 5 to 25 mm and a bulk density of 5 to 200 g/l by exposing crystalline polymers to ionizing radiation. X rays, electron beams, or neutrons at a dosage of 5 to 60 Mrad are suitable to produce the thermally stable expanded polymers. (B.L.M.)

16564 IONIC POLYMERIZATION IN IRRADIATED GLASSES. Perec, Liliana (CNRS, Paris). J. Chim. Phys.; 66: 1742-59 (Oct 1969). (In French).

The radioinduced polymerization of acrylonitrile and styrene was studied in different vitreous mixtures. In order to bring about an anionic polymerization of acrylonitrile, mixtures of this monomer with the following protonophilic solvents were used: N,N-dimethylformamide, triethylamine, isopropylamine. The polymerization of styrene was carried out in mixtures with chlorinated solvents hexachlorobutadiene and methylene chloride which are particularly suited for cationic reactions. For each system phase diagrams, reaction kinetics and mechanisms, and detailed conditions of the polymerization were examined. Glass transition temperatures ($T_g$) for the various systems were between −120° and 160°C. The influence of inhibitors and copolymerization data of acrylonitrile with methyl methacrylate in N,N-dimethylformamide demonstrate that the polymerization in this system proceeds by an anionic mechanism. The rate of polymerization of styrene in chlorinated solvents is strongly reduced in the presence of acetone and water. This fact suggests a cationic mechanism for this reaction. In all these systems the polymerization exhibits a peculiar behavior: the rate is very high when the high viscosity of the mixture favors chain propagation while retarding the termination step. (auth)

16565 FORMATION OF STABLE NITROGEN-CONTAINING RADICALS DURING CAPTURE OF RADICAL-PRODUCT NITRONES FORMED BY RADIOLYSIS OF LIQUIDS. Ershov, B. G.; Makarov, I. E. (Inst. of Physical Chemistry, Moscow). Izv. Akad. Nauk SSSR, Ser. Khim.; No. 10, 2296-7(Oct 1969). (In Russian).

The use of N, α-diphenylnitrone for the capture of free radicals produced by the γ-radiolysis of liquid systems was studied. Electron paramagnetic resonance and optical spectroscopy were used to study the radicals formed. (tr-auth)

16566 ELECTRON PARAMAGNETIC RESONANCE SPECTRA OF IRRADIATED CHILLED AQUEOUS SOLUTIONS. CAPTURED ELECTRONS IN POLYATOMIC ALCOHOLS AND THEIR AQUEOUS SOLUTIONS, WHICH WERE GAMMA-IRRADIATED AT 77°K. Makarov, I. E.; Ershov, B. G.; Pikaev, A. K. (Inst. of Physical Chemistry, Moscow). Izv. Akad. Nauk SSSR, Ser. Khim.; No. 10, 2170-5(Oct 1969). (In Russian).

Electron paramagnetic resonance was used to study the formation of captured electrons ($e^-_{capt}$) in polyatomic alcohols (ethylene glycol, glycerol, etc.) and their aqueous solutions, which were γ-irradiated at 77°K. Yields of $e^-_{capt}$ for vitreous matrices were approximately 1.5 independent of the alcohol and its content in the mixture of alcohol and water. Yields of organic free radicals were determined in vitreous glycol ether and its aqueous solutions. Distinctive characteristics of the radiochemical behavior of alcohol–water mixtures are discussed. (tr-auth)

16567 THE EFFECT OF $^{60}$Co GAMMA RADIATION ON ISOTOPIC EXCHANGE IN THE MOLECULAR OXYGEN–OXIDE SYSTEM. I. NEODYMIUM OXIDE. Antoshin, G. V.; Minachev, Kh. M.; Mashkevich, A. Ya.; Lokhuaru, M. E.; Dmitriev, R. V. (Inst. of Organic Chemistry, Moscow). Kinet. Katal.; 10: 991-6(Sep-Oct 1969). (In Russian).

Radiation-catalytic isotope exchange was studied in the system $O_2$–$Nd_2O_3$ in a gamma field at a dose rate of 200 rad/sec at 20 to 400°C and an oxygen pressure of 20 mm Hg. The activation energy of the exchange at 300 to 400°C was 24 ± 5 kcal/mole. In the temperature range from 20 to 300°C a negative temperature effect was observed with an activation energy of 4.2 ± 0.7 kcal/mole. (tr-auth)

16568 DYNAMIC POLARIZATION IN ELECTRON-IRRADIATED POLYCARBONATES. Draghicescu, M.; Draghicescu, P.; Grosescu, R.; Ianculovici, B.; Balla, D. (Inst. of Atomic Physics, Bucharest). Rev. Roum. Phys.; 14: 567-8(1969).

The dynamic polarization of free protons in polycarbonates $[-O-C_6H_4-C_3H_8-C_6H_4-O-CO-]_n$ is reported. The paramagnetic centers were obtained by low-energy (0.5-MeV) electron irradiation at liquid nitrogen temperature. (M.C.G.)

16569 LUMINESCENCE OF AQUEOUS SOLUTIONS OF SERUM ALBUMIN IN THE CASE OF SEPARATE AND JOINT INFLUENCES OF ULTRAVIOLET AND X RAYS. Buturlakin, M. S.; Shmelev, V. P. (Voronezh State Univ., USSR). Radiobiologiya; 9: 914-15(Nov-Dec 1969). (In Russian).

The luminescence method was used to detect a decrease in the radiolysis of an aqueous solution of serum albumin after a preliminary influence of ultraviolet rays at a dose of 0.3 W·sec/cm$^2$. It was found that in this case the amino acid residues of tyrosine and tryptophan make different contributions to the decrease in the radiolysis. (tr-auth)

16570 RADIOLYSIS IN THE ADSORBED STATE. III. METHYL IODIDE ADSORBED ON SILICA GEL. Sagert, N. H.; Reid, J. A.; Robinson, R. W. (Atomic Energy of Canada Ltd., Chalk River, Ont.). Can. J. Chem.; 48: 17-23(1 Jan 1970). (AECL-3484).

The $^{60}$Co γ radiolysis of methyl iodide adsorbed on silica gel was studied by examining the hydrocarbon products, which are mainly methane and ethane. These products are formed in large yields, indicating that a large fraction of the energy absorbed in the silica gel is able to cause decomposition of the methyl iodide. The energy transfer is thought to occur by electron or excitation transfer to the methyl iodide, leading to the production of methyl radicals. Evidence was obtained that the silica gel takes part in the system as a chemical reactant as well as being an energy transfer medium, and that changing the nature of the surface changes the course of the reaction. This is most clearly shown in two ways. The ratio of methane to ethane decreased as the surface hydroxyl concentration decreased, and it was concluded that excited methyl radicals form methane by abstraction of hydrogen from surface hydroxyls. Experiments using methyl iodide-$d_3$ adsorbed on protiated silica gel confirmed the participation of hydrogen from the silica gel, as the methane was over 85% $CD_3H$, while the ethane was over 95% $C_2D_6$. The effects of additives, such as $N_2O$ and $SF_6$, which are known to be electron scavengers, were also studied. It was found that methyl iodide is a much better electron scavenger than $N_2O$ and is as good an electron scavenger as $SF_6$ in this system. (auth) (Canada)

16571 CHEMICAL STATES OF $^{32}$P AND $^{35}$S IN NEUTRON IRRADIATED POTASSIUM CHLORIDE DOPED WITH POTASSIUM HYDROXIDE. Bracokova, V.; Cifka, J. (Inst. of Nuclear Research, Rez, Czech.). J. Inorg. Nucl. Chem.; 32: 365-8(Feb 1970).

The distribution of $^{32}$P and $^{35}$S atoms among their different valency states was studied as a function of increasing percentage of added potassium hydroxide in potassium chloride. The content of the various reduced species either changed very little or decreased in the range from 0.001 to 0.01 mol % of KOH, increased in the range from 0.01 to 0.1 mol % of KOH, and then decreased again. The different thermal annealing behavior of species with different contents of potassium hydroxide was also studied. (auth) (UK)

**16572** CHEMICAL STATES OF $^{32}P$ AND $^{35}S$ IN NEUTRON IRRADITATE BARIUM CHLORIDE. Cifka, J.; Bracokova, V. (Inst. of Nuclear Research, Rez, Czech.). J. Inorg. Nucl. Chem.; 32: 361-4(Feb 1970).

The distribution of $^{32}P$ and $^{35}S$ atoms in barium chloride doped with potassium chloride was very sensitive to the temperature; apparent changes in the distribution were observable even when samples were annealed at 10°C. A two-step oxidation of $^{32}P$ took place. The decrease of $^{32}P$ in the $P^{1+}$ fraction was balanced by an equivalent increase in the $P^{3+}$ and $P^{5+}$ fraction, contrary to the behavior of $^{32}P$ in potassium chloride. (auth) (UK)

**16573** RADIOLYSIS OF STEAM-WATER MIXTURES: EFFECT OF STEAM QUALITY. Cerrai, E.; Gadda, F.; Ronchetti, C.; Scaroni, A. (CISE, Milan). Energ. Nucl. (Milan); 16: 768-74 (Dec 1969).

Some of the results obtained in the field of water-chemistry experiments on steam-water mixtures are reported. Work described deals with the effects of steam quality on the radiolytic gas production; some considerations are also made on the influence of the concentration of hydrogen and oxygen in the feed water on the radiolytic behavior. (auth)

**16574** GAMMA-RAY INACTIVATION OF TRYPSIN IN SOLUTION: EFFECTS OF VARIOUS SCAVENGERS. Singh, B. B. (Bhabha Atomic Research Centre, Trombay, India); Kabi, A. Proc. Nat. Inst. Sci. India, Part B; 35: 291-7(Aug 1969).

The mechanism of inactivation of trypsin by ionizing radiations in aqueous solutions was investigated using scavengers for various radiolytic products of water. It was shown that OH radical scavengers, $CNS^-$ and $I^-$, offer better protection than alcohols and this difference could be explained on the basis of the reaction of the enzyme molecules with the radicals formed on alcohols. Electron scavengers also offered protection but to a lesser extent. Oxygen was found to be a better protector than $NO_3^-$. Iodoacetamide ($ICH_2CONH_2$) was shown to be by far the best protector because it scavenged $e_{aq}^-$ forming $I^-$, which subsequently scavenged the hydroxyl radicals. It was concluded that major species responsible for the inactivation are hydroxyl radicals although $e_{aq}^-$ cannot be altogether neglected. (auth)

**16575** RADIOLYSIS OF LIQUID METHANOL IN THE PRESENCE OF 1-OCTENE. MECHANISM OF GLYCOL AND FORMALDEHYDE FORMATION. Habersbergerova, A.; Kourim, P.; Teply, J. (Inst. of Nuclear Research, Rez, Czech.). Collect. Czech. Chem. Commun.; 34: 3657-63(Dec 1969).

Formation of glycol and formaldehyde in the radiolysis of liquid methanol was investigated in the presence of 1-octene reacting efficiently with free radicals, but not so much with electrons. The fact that the yield of glycol is nearly completely suppressed proves that this product is formed by combination of $CH_2OH$ radicals. The main products of the radiolysis of methanolic solution of 1-octene are alcohols possessing more than 9 carbon atoms (probably $C_7$-alcohols), 1-nonanol, and, in a transition range of octene concentrations, also 2-methyl-1-octanol, further octane, and hydrocarbons containing 16 carbon atoms. Essentially the reactions are not of a chain character and the radiation yield of the octene consumption is about 7. Formaldehyde is not formed by a radical mechanism, as its formation is not influenced by the presence of octene. The possibility is considered of its formation from $CH_2OH^+$ ion by proton transfer to methanol. (auth)

**16576** SZILARD-CHALMERS REACTIONS OF ZIRCONOCENE DICHLORIDE AND OF HAFNOCENE DICHLORIDE. Hillman, Manny; Weiss, Allen J.; Hahne, Rolf M. A. (Brookhaven National Lab., Upton, N. Y.). Radiochim. Acta; 12: 200-2(Dec 1969).

Retentions and isotope effects following (n,γ) reactions were measured for various isotopes of zirconium and hafnium as the biscyclopentadienyl metal dichlorides in the solid state and in solution with benzene and benzene-acetone as solvents. Retentions were also determined following (n,n') and (n,2n) reactions using 14 MeV neutrons. An unexpected isotope effect was observed in the 14 MeV neutron reactions. All results are compared with corresponding results previously obtained using phthalocyanines of these elements. (auth)

**16577** RADIATION GRAFTING OF POLYSULPHIDES TO WOOL. Samways, C.; Hastings, G. W. (Univ. of New South Wales, Kensington, Australia). Nature (London); 225: 634-5 (14 Feb 1970).

Successful attempts to graft polysulfide polymers (Thiokols) to wool are reported, and some mechanical properties of the product are described. Samples of merino fleece and woolen-cloth woven from merino wool were $^{60}Co$ gamma irradiated while immersed in a solution consisting of polymer, solvent, and swelling agent. Irradiations were carried out under $N_2$ and in the presence of air at dose rates up to 100 kR/kr. The solvents included dioxan, pyridine, and dimethylsulfoxide. The amount of grafting was found to be smaller under $N_2$ than in the presence of air. For absorbed doses of 20 to 30 MR and water concentrations of 10%, maximum weight increases of 2 and 12.7% resulted for irradiations under $N_2$ and in air, respectively. A steady decline in mechanical strength occurred as the radiation dose and amount of grafted polymer accumulated, but fibers irradiated in the same solvent-water solution, but without polymer, showed a much sharper decline in mechanical strength, implying that the added polymer had contributed towards improving the mechanical strength or had partially protected the fiber from radiation damage. The felting tendency of the polymer grafted wool was greater than that of untreated wool and increased with radiation dose. There was evidence of chemical combination of polymer with the wool. (UK)

**16578** CHEMICAL BEHAVIOR OF $^{51}Cr$ IN BENZENE SOLUTION OF NEUTRON-IRRADIATED TRISACETYLACETONATOCHROMIUM/III/. Omori, T.; Shiokawa, T. (Tohoku Univ., Japan). Radiochem. Radioanal. Lett.; 3: 39-44(11 Feb 1970).

In trisacetylacetonatochromium(III) the recombination reaction of the recoil $^{51}Cr$ atoms was investigated in the organic solution in which the neutron-irradiated target was dissolved. The retention values were affected by the time after solution, while extrapolation of the retention to zero time gave a constant value independent of the dissolving media. The existence of very labile recoil chromium species is also suggested by means of the ion exchange resin method. (auth)

**16579** PREPARATION OF CARRIER-FREE $^{77}Br$ FOR MEDICAL USE. Helus, F. (Hammersmith Hospital, London). Radiochem. Radioanal. Lett.; 3: 45-50(11 Feb 1970).

$^{77}Br$ is produced by bombardment of arsenic pentoxide targets in a 28-MeV α beam. The method of separating radiobromine from radioactive and chemical contamination is described. The yield of $^{77}Br$ obtained from a 1 hr bombardment at 20 μA is 3.2 mCi. (auth)

**16580** SZILARD-CHALMERS EFFECT ON XENON TRIOXIDE IN AQUEOUS SOLUTION. Heitz, Ch.; Cassou, M. (Centre de Recherches Nucleaires, Strasbourg). Radiochim. Acta; 12: 203-6(Dec 1969). (In French).

Aqueous solutions of xenon trioxide were irradiated in a thermal neutron flux of $10^{12}$ n $cm^{-2}$ $s^{-1}$. The retention of radioxenon is 3%. The variation of the enrichment factor of the radioisotopes of xenon in the gaseous phase with the irradiation time was determined. (auth)

**16581** PULSE RADIOLYSIS STUDIES OF URACIL AND ITS DERIVATIVES. PRIMARY SPECIES ATTACK. Greenstock, C. L.; Hunt, J. W.; Ng, M. (Univ. of Toronto, Ontario Cancer Inst., Toronto). Trans. Faraday Soc.; 65: 3279-87(1969).

The intermediates formed by ·OH, ·H and $e_{aq}^-$ attack on the pyrimidine uracil were observed and identified. Each shows a broad, weak absorption peaking at 385, 420, and 315 nm, respectively. As predicted by stationary-state radiolysis, ·OH and ·H addition occur at the 5,6-double bond, the bleaching of this chromophore coinciding with the appearance of the adducts. Three methods for determining the rates of ·OH attack on uracil and its derivatives were compared. In uracil, rates of $6.0 \times 10^9$, $6.5 \times 10^9$, and $5.0 \times 10^9$ $M^{-1}$ $s^{-1}$ were obtained for 5,6-double bond bleaching, build-up of ·OH-adduct and $CNS^-$ competition, respectively. The ·OH-adduct disappears by second-order kinetics with a rate constant $\sim 2 \times 10^9$ $M^{-1}$ $s^{-1}$. The rate of ·OH attack per base decreased slightly in oligo and polyuridylic acids. This contrasts with the large decrease in the rate of $e_{aq}^-$ attack and suggests a change in the site of ·OH attack in polynucleotides to the sugar phosphate backbone. (auth) (UK)

**16582** EFFECTS OF SOLVENT ON THE COPOLYMERIZATION OF ETHYLENE WITH TETRAFLUOROETHYLENE BY $^{60}Co$ GAMMA RADIATION. Hagiwara, Miyuki; Miura, Takeshi; Kagiya, Tsutomu (Japan Atomic Energy Research Inst., Takasaki). Bull. Chem. Soc. Jap.; 42: 3380-4(Dec 1969).

The $^{60}Co$, γ-induced copolymerization of ethylene with tetrafluoroethylene was carried out in the gas phase and in the liquid phase by using five solvents (liquefied carbon dioxide, carbon tetrachloride, ethyl chloride, chloropentafluoroethane, and 1,2-dichlorotetra-1,1,2,2-fluoroethane) at a dose rate of 25,000 RAD/hr under a pressure of 300 kg/$cm^2$ at 30°C. A lower rate of the copolymerization and a copolymer of a lower molecular weight were obtained in liquid carbon dioxide and carbon tetrachloride than in the gas phase without a solvent. In ethyl chloride, the rate increased slightly, but the molecular weight decreased. On the other hand, both the rate and the molecular weight increased

markedly in the fluorocarbon solvents. As a result of a detailed investigation of the copolymerization in 1,2-dichlorotetrafluoroethane, a linear increase in the copolymerization rate and the copolymer molecular weight with the amount of solvent was noted, and there was no noticeable influence of the solvent on the copolymer composition. A kinetic discussion indicated that the addition reaction of tetrafluoroethylene to radicals produced by the influence of primary radiation on the reaction mixture is an important step in initiating the copolymerization. Also, the propagation reaction seems to be strongly promoted by the fluorocarbon solvents. (auth)

**16583** EFFECT OF γ-PREIRRADIATION ON CATALYTIC ACTIVITY OF NICKEL OXIDE FOR THE OXIDATION OF CARBON MONOXIDE. Tezuka, Yoshisato; Takeuchi, Toyosaburo (Toyama Univ., Japan). Bull. Chem. Soc. Jap.; 42: 3447-50 (Dec 1969).

The change in NiO catalytic activity on the variation in the irradiation of γ rays in the presence of $O_2$ gas was studied. Activities were determined for the reaction of CO with NiO and for the oxidation reaction of CO on NiO. The results showed a decrease in the CO–NiO reaction rate with an increase in the irradiation of NiO, particularly in the absence of oxygen; if the irradiation was more than $7 \times 10^7$ R, the reaction rate increased as both the irradiation in the presence of oxygen and the oxygen partial pressure increased. The activity change in NiO was explained by assuming the migration of the specially-active oxygen into the oxide bulk by means of the irradiation with γ rays. (auth)

**16584** HYDRATED ELECTRON. Hart, Edwin J. (Argonne National Lab., Ill.). Surv. Progr. Chem.; 5: 129-84(1969).

Methods for production of hydrated electrons, their physical properties and structure, and their reactions with organic and inorganic compounds are discussed. (103 references). (M.C.G.)

**16585** RADIATION DAMAGE TO ELASTOMER GASKETS. Van de Voorde, M. (CERN, Geneva). Vakuum-Tech.; 18: 119-26(Jul 1969). (In German).

Studies were made on the effects of nuclear radiation on elastomers, as well as its influence on their chemical and physical properties. Certain applications in the field of accelerators are given in particular for vacuum chambers. The damages currently caused by radiation in the CERN proton synchrotron are described. (auth)

**16586** SEPARATION OF $^{207}Bi$ FROM A CYCLOTRON-IRRADIATED LEAD TARGET. Erlychenko, V. P.; Vinogradova, V. G.; Sevast'yanov, Yu. G. At. Energ. (USSR); 27: 349-51(Oct 1969). (In Russian).

Preparation of the 30-year half-life $^{207}Bi$ by deuteron irradiation of lead results also in the formation of $^{205}Bi$ and $^{206}Bi$ with $T_{\frac{1}{2}}$ = 14.5 and 6.4 days, respectively. A chemical treatment method was developed in order to separate the bismuth isotopes from the lead in the copper–lead alloy target. The $^{207}Bi$ was separated without carrier from a solution of nitrates containing tens of grams of lead, grams of copper, and radioactive $^{65}Zn$ impurities by coprecipitating it with iron hydroxide, using a nitric acid and pyridine mixture as reagent. After only one reprecipitation, the $^{207}Bi$ may be quantitatively separated from all impurities except for trace amounts of lead; the residual impurities may be removed by an anion exchange column. The $^{207}Bi$ solution obtained after washing the column with hydrochloric and nitric acids contains only 2 + 3 γ/ml of lead, with a $^{207}Bi$ yield of about 99%. (TTT)

**16587** RADIATION-INDUCED ALIPHATIC HYDROGEN ISOTOPE EXCHANGE BETWEEN t-BUTYL ALCOHOL AND SOLVENT WATER. Gold, V.; Rolston, J. H. (King's Coll., London). J. Chem. Soc., D.; No. 4, 208-9(18 Feb 1970).

A radioinduced aliphatic hydrogen exchange reaction has been found and certain features of its mechanism have been interpreted in terms of the formation of a solvated electron. (auth) (UK)

**16588** ENERGY AND CHEMICAL REACTION. I. DYNAMICS OF SIMPLE IONIC AND ATOMIC PROCESSES. Wolfgang, Richard (Univ. of Colorado, Boulder). Accounts Chem. Res.; 2: 248-56 (Aug 1969).

The effects of reactant energy on chemical reactions are reviewed including hot atom reactions and interactions with heavy energetic ion species. The discussion centers around 8 qualitative generalizations abstracted from identified quantitative trends of kinetic energy dependence. These concepts are presented in the framework of accounts of the dynamics of ion-molecule and atom-molecule reactions. Nuclear recoil methods are reviewed. In these techniques, a very high energy radioactive atom is produced by nuclear reaction. In the case of hydrogen, for example, the process $^3He + n \rightarrow p + T$ yields a tritium atom having an energy of the order of $10^5$ eV. This is generated in the medium in which it is to react by irradiating with neutrons a mixture containing $^3He$. The very fast atoms lose energy in successive collisions until they are reduced to less than 100 eV. They thus enter the chemical range from the top and undergo more collisions. These result either in reaction in which the hot atoms become incorporated in a labeled molecule or become thermalized. Chemical accelerator methods are also considered, as well as factors controlling hot-atom reactions. (BBB)

**16589** PRODUCTION AND REACTIONS OF ALKYL RADICALS FORMED IN ORGANIC GLASSES AT LOW TEMPERATURES BY gamma-RADIOLYSIS AND BY PHOTOLYSIS. French, William George. Madison, Wis.; Univ. of Wisconsin (1969). 172p.

Thesis.

Trapped free radicals were produced in saturated hydrocarbon glasses at 77°K by irradiation of the glass with $^{60}Co$ γ rays, by hydrogen abstraction from the matrix molecules by hot atoms or radicals formed by photodissociation of hydrogen iodide or alkyl iodides, and by dissociative electron capture by alkyl halides dissolved in the matrix. Photoionization of a dissolved aromatic amine or γ irradiation of the matrix was used as an electron source in the latter reaction. Through electron spin resonance studies of the kinetics of trapped radical decay, two predominate decay mechanisms were discovered. Radicals produced by γ irradiation of a pure hydrocarbon matrix are trapped with an average separation greater than 5 molecular diameters, and decay by random combination with other radicals. Radicals produced by photodissociation or dissociative electron capture reactions are trapped very near their halide atom or ion partner and decay by geminate recombination with this partner at a rate determined mainly by the properties of the matrix. The mechanism of radical production in the irradiation of a pure alkane glass is probably an ion-molecule reaction of the type: $C_6H_{14} + C_6H_{14}^+ \rightarrow C_6H_{13} + C_6H_{15}^+$. This mechanism, which is exothermic and not reversible at 77°K, can lead to radicals separated by more than 5 molecular diameters. Radicals that result from dissociative electron capture are formed with energies in excess of thermal energies at 77°K, and they may abstract hydrogen from the matrix molecules before this excess energy is lost and the radicals become trapped. Trapped radicals do not abstract hydrogen at 77°K. The yields of trapped radicals formed by dissociative electron capture during the photoionization of tetramethyl-p-phenylenediamine (TMPD) are dependent on the degree of complex formation between the alkyl halide and the amine. The main effect of this complex is the inhibition of photoionization due to shortening of the lifetime of the first excited triplet state of the TMPD. The trend of degree of complexing is RCl < RBr < RI, so that the trend of radical yields is RCl > RBr > RI. No hydrogen-deuterium isotope effect is observed on the yield of radicals produced by γ irradiation or by dissociative electron capture, nor is an effect observed on the decay kinetics of radicals which combine randomly with other radicals, but deuterated matrices stabilize $CH_3$ and $C_2H_5$ radicals, formed by dissociative electron capture, much more effectively than protiated matrices. (Disser. Abstr.)

**16590** KINETICS OF SOLVATED ELECTRONS AND HYDROGEN ATOMS IN RADIOLYZED METHANOL. Suryanarayanan, Kalyanasundaram. Boston; Boston Univ. (1969). 151p.

Thesis.

The effect of $H_2SO_4$ on yields of $H_2$, $CH_4$, $CH_2O$, and ethylene glycol produced in γ radiolysis of air-free methanol was studied. Addition of acid increased the yields of $H_2$, $CH_2O$, and ethylene glycol; and the yields eventually became limiting. No significant effect on the yield of methane was observed. $G(CH_4)$ in neutral air-free methanol is 0.50. The yields per 100 eV of other products when there is no added acid are: $H_2$, 4.91; $CH_2O$, 2.10; ethylene glycol, 2.66. The limiting yields of the products in the presence of acid are: $G(H_2)$, 5.79; $G(CH_2O)$, 2.39; G(glycol), 3.39. The half-maximum values of $H_2$, $CH_2O$ and ethylene glycol are obtained at about $4 \times 10^{-5}$, $8 \times 10^{-5}$ and $4 \times 10^{-4}$ M $H_2SO_4$ respectively. The concentration of $H_2SO_4$ at which the half-maximum value of $H_2$ is obtained indicates that the species responsible for the increase in yield on adding acid is homogeneously distributed in bulk solution. In order to kinetically identify this species and to determine the yields of $G_{H_2}$, $G_{e_s^-}$ and $G_H$, competition studies employed oxygenated neutral and acidic methanol. Studies of the system, methanol-$3.8 \times 10^{-2}$ M acid-varying oxygen, yielded $G_H + G_{e_s^-} = 4.0 \pm 0.3$ and $k_{H+O_2}/k_{H+CH_3OH} = (5.6 \pm 0.6) \times 10^3$. Most of the measurements on this system were carried out with sulfuric acid. Studies of neutral oxygenated methanol yielded $G_H = 2.02 \pm 0.18$ and $k_{H+O_2}/k_{H+CH_3OH} = (6.0 \pm 0.9) \times 10^3$ from the competition data at oxygen concentrations of the order of millimolar and above. Studies on the system, methanol-0.95 to 1.0 mM oxygen-varying sulfuric acid concentration, such that competition for electrons of oxygen and acid is

significant, yielded $G^-_{e_s} = 1.4_5 \pm 0.30$ and $k^-_{e_s} + c_3/k^-_{e_s} + CH_3OH^+ = 0.3_5 \pm 0.11$. Competition studies also indicated that the additional hydrogen yield obtained in the presence of acid could be derived from solvated electrons or other species with identical kinetic behavior. Pulse radiolytic studies of decay of the solvated electron in methanol were carried out. Decay traces were obtained after repeated pulsing on the same sample, and measurements of the absorption due to solvated electron were made at 545 nm. The repeated pulsing had no effect on the half-life of the methanolic electron, and clean first order decay was observed. Pulse experiments carried out with methanol which had been subjected to a dose of $1.5 \times 10^{19}$ eV/cc from a $\gamma$ source and then rectified also gave the same value for the half-life of the solvated electron. Pulse experiments carried out in methanol failed to indicate any transients in the wavelength region 250 to 370 nm. (Disser. Abstr.)

**16591** ELECTRON-NUCLEAR DOUBLE RESONANCE IN RADIATION-DAMAGED ACETYLGLYCINE. Piazza, Richard Elliot. Amherst, Mass.; Univ. of Massachusetts (1969). 59p. Thesis.

Samples of acetylglycine ($CH_3CONHCH_2COOH$) were cleaved from crystals grown by slow evaporation of aqueous solution, and radiation damage in these samples was effected by exposure to several million R of $\gamma$ rays from a 2.5 kCi $^{60}Co$ source. The sample temperature was reduced to that of liquid nitrogen and ESR of $CH_3CONHCHCOOH$, the free radical in radiation-damaged acetylglycine, was initiated by means of suitable microwave and magnetic fields. While monitoring the ESR signal an additional variable frequency rf field was used to explore the rf spectrum for possible nuclear resonances. A set of 13 lines was observed in the 8 to 25 MHz range investigated. Measurement of ENDOR (electron-nuclear double resonance) frequencies as a function of magnetic field direction was made for three planes through the sample and served to define two sets of coupling tensors, each set consisting of three nearly equivalent coupling tensors. The tensors were derived by a computer fit to data in the three planes. The sets of coupling tensors were observed to possess a twofold rotational relationship appropriate to the crystal structure of acetylglycine. In addition, the tensors were indicative of weak electron couplings to protons which are not discernible in the conventional ESR spectrum. These results are interpreted as signifying a weak interaction between the unpaired electron spin and the three nearly equivalent protons of the rotating methyl group. An unpaired electron spin distribution throughout the molecule is determined on the basis of this model such that its coupling to the methyl group agrees both in magnitude and direction to the experimental results. (Disser. Abstr.)

**16592** THE CHEMISTRY OF SEVERAL HYDROXOCHLOROPLATINATES(IV) AND THEIR USE IN THE ISOLATION OF CARRIER FREE $^{197}Pt$. Armento, William Joseph. Atlanta; Georgia Inst. of Tech. (1969). 343p. Thesis.

The application of a Szilard-Chalmers reaction to both platinum and palladium to produce carrier free radioisotopes was investigated. Platinum metal was irradiated with 14-Mev neutrons to carry out the reaction. The hexachloroplatinate (IV) complex was synthesized and allowed to sit in an aqueous solution for 8 to 24 hr with no excess of chloride ion present. The daughter was then separated from the hexachloroplatinate (IV) solution as a complex of the form $Pt(IV)Cl_x(OH)_{6-x}^{2-}$, where x was from 0 to 4. Three complexes were synthesized to use in studying the separation: 1) the hexachloroplatinate(IV); 2) the dihydroxotetrachloroplatinate (IV); and 3) the hexahydroxoplatinate(IV). These complexes were prepared as the sodium salts and analyzed to verify the composition. The complexes were separated on a column packed with paper cellulose and using a combination of solvents. The $R_f$ value in the cellulose column was inversely proportional to the volume of solvent needed to elute the material off of the column. For any complexes that remained on the column, a dilute solution of sodium iodide and hydrochloric acid converted the complex to hexaiodoplatinate(IV) which could be eluted off of the column immediately. In order to use the separation of the platinum complexes most effectively, accurate half-lives and cross sections were needed. Since the neutron generator gave the best source of activity, only the fast neutron cross sections for the (n,2n) reactions on $^{198}Pt$ were needed. The use of the generator was preferred even though the flux was very much lower because the resulting radiochemical purity of the $^{197m}Pt$ was so much greater. The cross sections were measured for the fast neutron reactions and found to be 1.18 and 1.01 barns for formation of $^{197m}Pt$ and $^{197g}Pt$, respectively. It appeared that some enrichment from the Szilard-Chalmers reaction had been obtained, but carrier free $^{197g}Pt$ was not obtained. The enrichment factor was very small, but showed that further experimentation might lead to a better scheme for enrichment. (Disser. Abstr.)

**16593** LABELLED FRAGMENTS FORMATION FROM n-ALKANES BY RECOIL TRITIUM ATOMS. Avdonina, E. N.; Urch, D. S.; Winter, G. K. (Queen Mary Coll., London). Radiochim. Acta; 12: 215-16(Dec 1969).

The yields of labeled fragments formed by the reactions of tritium atoms with n-hexane are tabulated. Two possible explanations for the formation of unscavengeable low-molecular-weight hydrocarbons are proposed. The data indicate that the only products of the T atom reactions with solid parent compounds are labeled alkanes with yields decreasing with increasing number of C atoms. The reaction with liquid hexane produces lower yields as compared with the solid-state results, and some unsaturated low-molecular-weight hydrocarbons appear in relatively small yields. Only relative yields are reported for the gas-phase studies. (B.L.M.)

**16594** HIGH INTENSITY GAMMA IRRADIATION OF MOLTEN SODIUM FLUOROBORATE–SODIUM FLUORIDE EUTECTIC SALT. Compere, E. L.; Savage, H. C.; Baker, J. M. (Oak Ridge National Lab., Tenn.). J. Nucl. Mater.; 34: 97-100(Jan 1970).

The effects of $\gamma$ radiation on the $NaBF_4$–NaF eutectic, which is proposed for use as a coolant in a molten salt reactor, were studied. The eutectic was sealed in a Hastelloy N capsule containing a Hastelloy N corrosion test specimen to determine the compatibility of the eutectic with proposed containment materials. The surface of the metal container and of the corrosion specimen showed no evident attack, and the weight loss was negligible indicating no $\gamma$-induced incompatibility between the eutectic and Hastelloy N to a dose of $7.7 \times 10^{10}$ R with an average intensity of 0.15 W/g and a maximum intensity of 0.5 W/g. The results of neutron irradiation test on $BF_3$ were extrapolated to postulate that no quantity of $F_2$ that could not be tolerated would result from neutron irradiation of the eutectic if used as a coolant in the reactor. (B.L.M.)

**16595** CHEMICAL EFFECTS OF NUCLEAR REACTION IN ORGANOHALOGEN COMPOUNDS. Yagi, Masuo; Kondo, Kenjiro (Tohoku Univ., Sendai). Res. Rep. Lab. Nucl. Sci., Tohoku Univ.; 1: No. 1, 72-3(1968). (In Japanese).

Basic investigations were carried out with regard to the chemical effect in the $^{80m}Br \xrightarrow{IT} {}^{80}Br$ and $^{81}Br(\gamma,n)^{80m}Br$ systems. The chemical effect of nuclear isomeric transition of $^{80m}Br$ was studied in the system of $C_2H_5{}^{80}Br - Br_2$. From the recorded scavenger curve, it was observed that the organic yield was higher in the solid phase at the temperature of –196°C than in the liquid phase at a room temperature. In order to get some information on the fragmentation caused by nuclear transmutation, the radiochromatograms of irradiated ethyl bromide were compared with the cases of already known (n,$\gamma$) reaction and IT. The characteristics are the high yield of dibromide and tribromide, and the appearance of new peaks which seem to be attributable to olefin bromides. It was noted that 50 to 60% of radioactive bromine appeared in unknown compounds of high boiling points, identification of which was significant for determining the recombination reaction mechanism of recoil bromine atoms. Three compounds were separated by paper chromatography and thin layer chromatography. They appeared to be bromine compounds with more than three phenyl groups, though they have not been positively identified. (NSA of Japan)

**16596** RADIATION CHEMISTRY OF FOODS. PART 3. RADIOLYSIS OF SULFUR-CONTAINING AMINO ACIDS IN AQUEOUS GLUCOSE SOLUTION. Tajima, Makoto; Morita, Makio (Tokyo Univ.). Agr. Biol. Chem. (Tokyo); 33: 1277-81(Sep 1969).

When $10^{-3}$ M cysteine solution containing a ten-fold excess of glucose was irradiated, the G-values of products produced from cysteine were similar to those from $10^{-3}$ M cysteine solution. On the other hand, the yield of carbonyl compound from glucose was suppressed completely by interaction between cysteine and radicals secondarily produced from glucose. Methionine could not suppress the yield of carbonyl compound from glucose, and, G-values of products from methionine varied in comparison with those from solution containing methionine only. From the results using $e^-_{aq}$ scavenger, it was concluded that oxidation to methionine sulfoxide and cleavage to $\alpha$-aminobutyric acid was caused by ·OH and $e^-_{aq}$ attack, respectively. (NSA of Japan)

**16597** LOW-TEMPERATURE SOLID-PHASE RADIATION POLYMERIZATION IN BINARY SYSTEMS. Nekhoroshev, V. G.; Sheinker, A. P.; Abkin, A. D. (Inst. of Physics and Chemistry, Moscow). Vysokomol. Soedin., Ser. B; 11: 736-40(Oct 1969). (In Russian).

Studies were made on the radioinduced polymerization of acrylamide in the presence of water at –21 to –196°C. The rate of polymerization in the system acrylamide–water increased sharply depending on the amount of water in the initial mixture

and reached a maximum at a content of about 6 mole %. The activation energy for the polymerization process close to eutectic was 18 kcal/mole at about −20°C. At temperatures below −60°C, the activation energy was close to zero. The dependence of the rate of polymerization in eutectic composition was found to be a function of noneutectic properties of crystals of one of the components. It was concluded that low-temperature polymerization of acrylamide in the presence of water proceeds on the surface of the section of eutectic crystals of the monomer and water. (tr-auth)

**16598** RADIATION GRAFTING OF CELLULOSE WITH ACROLEIN IN VAPOR PHASE AND PROPERTIES OF DERIVATIVE PRODUCTS. Ishanov, M. M.; Azizov, U.; Nikonovich, G. V.; Usmanov, Kh. U. Vysokomol. Soedin., Ser. B; 11: 763-7(Oct 1969). (In Russian).

The radiation grafting of cellulose with acrolein in the vapor phase proceeded without formation of homopolymers. When the weight was increased the angle of transition increased while strength and elongation decreased. During the grafting reaction the vinyl group participates with the aldehyde groups of acrolein. Previously it was found that the molecular structure of acroelin radiopolymerized with cotton cellulose showed essential changes in the structure, typical for the cellulose preparations containing crosslinked bonds. (tr-auth)

**16599** MASS SPECTROMETRIC INVESTIGATION OF THERMAL DECOMPOSITION OF γ- AND NEUTRON-IRRADIATED POLYSTYRENE. Muinov, T. M.; Narzulaev, B. N.; Amelin, A. V.; Glagoleva, Yu. A. (Ioffe Inst. of Physics and Tech., Leningrad). Vysokomol. Soedin., Ser. B; 11: 771-4(Oct 1969). (In Russian).

Mass spectrometry was used to study the kinetics of the initial stage of the thermal decomposition of γ- and neutron-irradiated polystyrene, and the results were correlated with the kinetics of the thermal decomposition of nonirradiated polystyrene. The energy of activation of the initial stage in the thermal decomposition of irradiated polystyrene up to the evaporation of 20 to 30% was found to have a low value (32 to 33 kcal/mole), which corresponds to the breaking of weak bonds. (tr-auth)

**16600** EFFECTS OF MATRIX BACKING ON ORIENTATION OF GRAFTED CHAINS IN LIQUID-PHASE RADIOINDUCED COPOLYMERIZATIONS. Kabanov, V. Ya.; Aliev, R. E.; Kazimirova, N. M. Vysokomol. Soedin., Ser. B; 11: 834-7(Nov 1969). (In Russian).

The results showed that grafted poly(2,3-epoxypropyl methacrylate) chains radioinduced in the liquid phase on oriented polyethylene are partially oriented. It was concluded that the solvent has an essential effect on the orienting action of the support in relation to chain grafting. New functional groups that were introduced in grafted chains by means of conversion of the epoxy ring reduced the magnitude of dichroism of the spectral band, describing the oscillations C = O, but did not eliminate it completely. (tr-auth)

**16601** STUDIES ON THE PREPARATION OF SPECIAL RADIOISOTOPE $^{47}Ca$, ETC. Shiokawa, Takanobu; Omori, Takashi (Tohoku Univ., Sendai). Res. Rep. Lab. Nucl. Sci., Tohoku Univ.; 1: No. 2, 119-21(Dec 1968). (In Japanese).

To produce very pure $^{47}Ca$ in neutral solutions, 10 mg of $CaCO_3$ enriched with $^{48}Ca$ was placed in a quartz ampule and irradiated with bremsstrahlung of 45 MeV and 50 and 150 μA for 6 hr. The HCl solution of the irradiated carbonate was evaporated to dryness and the residue was taken up in water and dried, repeatedly. The $^{47}Ca$ produced by the (γ,n) reaction with the enriched Ca was very pure (>99.9%) and devoid of $^{48}Ca$. (NSA of Japan)

**16602** GRAFT-POLYMERIZATION ONTO FLUORINE RESINS WITH RADIATION. Yasukawa, Tamio; Murakami, Kenkichi (Tohoku Univ., Sendai). Res. Rep. Lab. Nucl. Sci., Tohoku Univ.; 2: 138-40(Jun 1969). (In Japanese).

Styrene or its methanol solutions was grafted onto pre-irradiated fluorine resins, e.g., teflon and poly(vinylidene fluoride). The resins were pre-irradiated in a LINAC and sealed in an evacuated tube with the styrene solutions. After evacuation, the mixture was heated to 80°C for 5 hr. The grafting ratio was determined by IR spectral studies, and for methanol solutions of styrene and teflon, the grafting ratio increased up to 30% methanol and then decreased. Different results were obtained with poly(vinylidene fluoride). The grafting ratios of styrene in methanol with teflon could not be explained by the Trommsdorf effect alone; and it is assumed that the reacting liquid entered only the surface layer of teflon to cause swelling, which resulted in a decrease in the concentration of the methanol and thus a small grafting ratio. (NSA of Japan)

**16603** IRRADIATION PROCESS FOR PREPARING GRAFT COPOLYMERS. Tanner, David (to E. I. du Pont de Nemours and Co.). U. S. Patent 3,488,268. 6 Jan 1970. Filed 2 Dec 1965.

A process is described for preparing graft copolymers by exposing a mixture containing (A) a solid shaped structure of a water-insoluble synthetic condensation product having recurring $-\overset{|}{N}-$ atoms as an integral portion of the polymer chain, (B) an ethylenically unsaturated organic acidic compound or salt thereof, and (C) from about 0.001 to 10% by weight of a free radical polymerization inhibitor selected from quinones, polyphenols, aromatic nitro compounds, dithiocarbamates, sulfur, ionol, and Methylene Blue to 0.01 to 0.160 Mrad of ionizing radiation. Suitable condensation products include polyamides, polyurethanes, polyureas, and polysulfonamides. (Official Gazette)

**16604** ON THE OXYIODINE RADICALS IN AQUEOUS SOLUTION. Amichai, O.; Treinin, A. (Hebrew Univ., Jerusalem). J. Phys. Chem.; 74: 830-5(19 Feb 1970).

The flash photolysis of $IO_3^-$ and $IO^-$ provides evidence for the following primary processes: $IO_3^- \xrightarrow{h\nu} IO_2 + O^-$ and $IO^- \xrightarrow{h\nu} I + O^-$. These are followed by secondary reactions involving the parent ions. $O^-$ (or OH) reacts with $IO_3^-$ and $IO^-$ to yield $IO_3$ and IO, respectively; the rate constants of these reactions could be determined by studying the $O_3^-$ decay in alkaline solutions containing $O_2$. $IO_3$ and $I_2^-$ (produced from I in presence of $I^-$) react with $IO_3^-$ and $IO^-$, respectively, to yield IO. The spectra and decay kinetics of the oxyiodine radicals were also studied by pulse radiolysis. The two techniques lead to the same conclusions. (auth)

**16605** IONIZATION OF LIQUIDS BY RADIATION STUDIED BY THE METHOD OF PULSE RADIOLYSIS. III. SOLUTIONS OF GALVINOXYL RADICAL. Capellos, C. (Picatinny Arsenal, Dover, N. J.); Allen, A. O. J. Phys. Chem.; 74: 840-5(19 Feb 1970).

The yield of galvinoxyl anion, found by pulse radiolysis of dilute solutions of galvinoxyl radical in various hydrocarbon solvents, was equal to the total yield of ion pairs formed by irradiation in the same solvents, as determined by electrical methods. Galvinoxyl radical thus being shown to be an excellent electron scavenger, the method was applied to determine ion yields formed by radiation in other liquids, including alcohols and nitro compounds. From the ion yields, relative values of the mean charge-separation distances were calculated and were found to be smaller the more polar the liquid. (auth)

**16606** MECHANISM OF REACTION OF HYDROXYL RADICALS WITH BENZENE IN THE γ RADIOLYSIS OF THE AERATED AQUEOUS BENZENE SYSTEM. Balakrishnan, I.; Reddy, M. P. (National Chemical Lab., Poona). J. Phys. Chem.; 74: 850-5 (19 Feb 1970).

The reaction of hydroxyl radicals with benzene in aerated aqueous solutions under γ radiolysis produces phenol and β-hydroxymucondialdehyde (βHMD). The respective G values are 1.7 and 1.2, in 0.8 N $H_2SO_4$, and 1.78 and 0.7, in neutral solutions, the sum of the two yields accounting for all the OH radicals in each instance. The enhancing effect of ferrous ions on these yields was correlated with the peroxide chain mechanism advanced originally to account for the influence of organic impurities on the $G(Fe^{3+})$ of the Fricke dosimeter. At a benzene concentration of $10^{-2}$ M and a ferrous ion concentration of $10^{-3}$ M, $G(Fe^{3+})$ is ~48; G (phenol) and G(βHMD) are 8.8 and 6.6, respectively. This corresponds to a chain length of ~2. (auth)

**16607** CHARGE TRANSFER TO MOLECULES ON THE SURFACE OF IRRADIATED POROUS GLASS. Wong, P. K.; Allen, A. O. (Brookhaven National Lab., Upton, N. Y.). J. Phys. Chem.; 74: 774-8(19 Feb 1970).

Tetracyanoethylene (TCNE) adsorbed on porous Vycor glass forms under γ rays at room temperature its radical anion $TCNE^-$ with a yield G = 6.5 ions per 100 eV absorbed in the glass, independent of the surface concentration of TCNE. When the glass is first irradiated alone and the TCNE then added, the anion still forms with a yield G = 4.2. Presence of TCNE during irradiation prevents formation of the sharp trapped electron spin resonance (esr) signal characteristic of irradiated glass, but when TCNE is added to irradiated glass, the trapped-electron signal is not affected, although the signal characteristic of $TCNE^-$ appears with an intensity around 5 times that of the trapped electron signal. Thus the electron-donating centers formed on the glass surface are not trapped electrons seen by esr. Tetra-N-methylphenylenediamine (TMPD), triphenylamine, and perylene adsorbed on the glass form under γ rays radical cations stable at room temperature. Methylaniline, diethylaniline, and triphenylphosphine yield cations, and acetone, butanone, and acetophenone yield anions when

irradiated on the glass at 77°K, but these ions disappear when warmed to room temperature. (auth)

**16608** ENERGY TRANSFER IN RADIATION CHEMISTRY. Burton, Milton; Funabashi, Koichi; Hentz, Robert R.; Ludwig, Peter K.; Magee, John L.; Mozunder, Asokendu (Univ. of Notre Dame, Ind.). pp 161-218 of Transfer and Storage of Energy by Molecules. Vol. I. /Burnett, George M. (ed.). New York; John Wiley and Sons, Inc. (1969).

Topics covered include: energy transfer from the incident charged particle, theoretical concepts of energy flow in tracks, migration of electronic energy (special effects in tracks), energy transfer to scintillators, and energy transfer effects in chemical yields. It is shown that high-energy radiation deposits energy in a condensed system in a nonrandom way (i.e., in a track) and that many of the effects characteristic of radiation chemistry are directly attributable to such nonrandom energy deposition. (M.C.G.)

**16609** THE RADIOLYSIS OF GASEOUS TRIFLUOROIODOMETHANE IN THE PRESENCE OF NITRIC OXIDE. McAlpine, I.; Sutcliffe, H. (Univ. of Salford, Eng.). J. Phys. Chem.; 74: 848-50(19 Feb 1970).

Nitric oxide reduces the 100-eV yields of tetrafluoromethane and difluorodiiodomethane and increases the yield of iodine in the radiolysis of trifluoroiodomethane. The products nitrogen, nitrogen dioxide, trifluoronitrosomethane, trifluoronitromethane, and hexafluoroethane are also identified. A radical-chain mechanism involving an intermediate diazonium nitrate is proposed to explain the formation of these products and the high value of G(−NO). It is suggested that nitric oxide is acting as a scavenger of excited radicals. (auth)

**16610** RADIOAKTIVNYE IZOTOPY MAGNII-28 I FTOR-18. ($^{28}$Mg and $^{18}$F Radioisotopes). Sokolov, V. A.; Kozyreva-Aleksandrov, L. S. Moscow; Atomizdat (1969). 72p.

Fluorine-18 and $^{28}$Mg belong to a group of very promising radioisotopes that have found application in biology, medicine, and other scientific disciplines. The properties, methods of preparation, separation from irradiated targets, and also the method of labeling organic and inorganic compounds with these isotopes are described. Examples of applications and future uses are discussed. (61 references). (tr-auth)

**16611** PRODUCTION METHOD FOR $^{128}$I. Domondon, Domingo B. (Philippine Atomic Research Center, Quezon City). Philippines Nucl. J.; 2: 129-35(1969).

A procedure for the routine preparation of $^{128}$I was developed at the Philippine Atomic Research Center (PARC). Up to one (1) g potassium iodide targets, which were irradiated at a neutron flux of approximately $1 \times 10^{12}$ n/cm$^2$/sec for 50 min were processed by passing the dissolved KI through two Dowex-50 × 8 (50−100 mesh) resin columns in series. The first resin column was converted to its H+-form; the second, to its Na+-form. The product was in the form of Na$^{128}$I solution. More than 90% of the $^{128}$I activity was recovered in 15 cc volume, after discarding the first 5 cc effluent. Radiochemical purity of the product was checked by gamma spectrometry and by half-life determination. (auth)

**16612** ELECTRON SPIN RESONANCE INVESTIGATIONS ON RADIATION INDUCED FREE RADICALS OF CHOLESTEROL IN LIQUID PHASE. Hellinger, Otto; Heusinger, Helmut; Hug, Otto (Gesellschaft fuer Strahlenforschung mbH, Neuherberg, Ger. Technische Hochschule, Munich). Biophysik; 6: 193-206(1970). (In German).

The reaction kinetics of free radicals radioinduced in cholesterol in the liquid phase at room temperature was studied by ESR spectroscopy. The free radicals of cholesterol that were generated by the filtered uv radiation from a Xe high pressure lamp (235 nm ≤ λ ≤ 265 nm) were the same as those observed a decade ago by others in x-irradiated cholesterol powder. At sufficiently high $O_2$ pressures (≥$3 \times 10^{-4}$ torr) over the sample solution, a peroxy radical ESR spectrum arose during uv irradiation that was identified by product analysis (7-hydroxycholesterol and 7-ketocholesterol) to be due to a cholesteryl-7-peroxy radical. The velocity constant for bimolecular decay of the cholesteryl-7-peroxy radical was found to be $k_2 = (1.8^{+1.2}_{-0.9}) \cdot 10^8$ sec$^{-1}$ M$^{-1}$ at room temperature. It was also found that the cholesteryl-7-peroxy radical was formed by the addition of one molecule of $O_2$ to a cholesteryl-7 free radical. For this reaction a value of $k_1 = 0.4 \cdot 10^{10}$ sec$^{-1}$ M$^{-1} \cdot$ l was estimated as a lower limit of the velocity constant. (auth)

**16613** RADIATION-INDUCED POSTPOLYMERIZATION OF NITROETHYLENE. Yamaoka, Hitoshi; Obama, Isamu; Hayashi, Koichiro; Okamura, Seizo (Kyoto Univ.). J. Polym. Sci., Part A-1; 8: 495-503(Feb 1970).

The radioinduced postpolymerization of nitroethylene in 2-methyltetrahydrofuran glass has been studied and discussed in reference to the results obtained from ESR measurements. No postpolymerization occurred at the temperature below −150°C. In the temperature range between −135°C and −78°C, the polymer yield decreased with increasing postpolymerization temperature. The polymer yield increased linearly with the increase of the preirradiation dose in the range below $0.9 \times 10^6$ R. The mean value for chain initiation was estimated to be about 1.3. The following correlations were observed between the results of the postpolymerization and ESR measurements. The postpolymerization started in the temperature range between −140 and −135°C, where the ESR spectrum due to the anion radicals of nitroethylene disappeared. The polymer yield of the postpolymerization decreased with the photoirradiation at −196°C before warming the samples in parallel with the photobleachability of the anion radicals observed in the glassy mixture by the ESR method. It was concluded from these results that the radioinduced postpolymerization was initiated by the anion radicals of nitroethylene formed by the capture of electrons. (auth)

**16614** EFFECT OF HYDROGEN ON THE γ-RADIATION-INDUCED POLYMERIZATION OF ETHYLENE. Mitsui, Hiroshi; Hosoi, Fumio; Kagiya, Tsutomu (Japan Atomic Energy Research Inst., Takasaki). J. Polym. Sci., Part A-1; 8: 451-61(Feb 1970).

The effects of hydrogen on the γ-radioinduced polymerization of ethylene were studied from the viewpoint of polymer structure and kinetics. All experiments were carried out at 30°C. In the polymerization of ethylene containing 21.6% hydrogen, the solid polymer was obtained as a main product, while no liquid product was found. There was no difference in hydrogen contents before and after the irradiation; and acetylene, ethane, butane, and 1-butene were found as gaseous products. The polymer yield increased almost proportionally with dose rate in the presence of 8.0% hydrogen; on the other hand the molecular weight was independent of dose rate. At hydrogen contents of 0 to 8%, the polymerization rate increased with reaction time and decreased with hydrogen content. The molecular weight also increased with the time, and the extent of the increment decreased with the time and hydrogen content. The number of moles of polymer chain increased proportionally with the reaction time and increased linearly with hydrogen concentration. These results were analyzed by using a graphical evaluation method for kinetics, and the effects of hydrogen on the each elementary step in the polymerization were discussed. (auth)

**16615** PULSE RADIOLYSIS STUDIES ON REACTIVE INTERMEDIATES IN ORGANIC CHEMICAL PROCESSES. Adams, G. E. (Mount Vernon Hospital, Northwood, Eng.). Annu. Rep. Chem. Soc. Sect. B; 65: 22-30(1968).

Recent applications of pulse radiolysis to problems in organic chemistry are reviewed, including the study of oxidation and reduction processes in alphatic, aromatic, heterocyclic, and polymeric molecules, involving the formation of neutral, anionic and cationic intermediates also short-lived excited singlet and triplet states produced in irradiated compounds under a variety of conditions, and their role in energy transfer processes. Electron, H-atom, and proton transfer reactions occurring in both polar and nonpolar media are also discussed. The literature reviewed is classified according to processes occurring in the gas phase, in aqueous solution, in non-aromatic and aromatic solvents, and in some biochemical and biological systems. (70 references) (UK)

**16616** THE RADIATION-INDUCED ISOMERIZATION OF 1-BROMOBUTANE BY A FREE RADICAL CHAIN REACTION. Martin, Donald H.; Williams, Ffrancon (Univ. of Tennessee, Knoxville). Contract AT(40-1)-2968. J. Amer. Chem. Soc.; 92: 769-74(25 Feb 1970). (ORO-2968-45).

It was shown that the radioinduced isomerization of 1-bromobutane to 2-bromobutane is an autocatalytic reaction in which hydrogen bromide functions as a chain transfer agent. The reaction was studied as a function of dose, dose rate, temperature, and added hydrogen bromide concentration. Free radical scavengers (DPPH and iodine) inhibit the chain reaction. The presence of hydrogen bromide is essential to chain propagation, and experiments with tritiated HBr show that the tritium atom is transferred from TBr to give both 2-bromobutane and 1-bromobutane as radioactive products. A limiting rate of isomerization is reached at [HBr] > $10^{-3}$ M. In the absence of added hydrogen bromide, the concentration of butenes and HBr each attains a stationary value at very low doses (ca. $6 \times 10^{-4}$ M at 30°). The butene products include cis- and trans-2-butene in addition to 1-butene. It is proposed that bromoalkyl radicals undergo rearrangement through a series of reversible steps that involve elimination of a bromine atom, olefin isomerization, and readdition of Br. (auth)

16617 TRANSIENT BROMINE ATOM CHARGE-TRANSFER COMPLEXES OBSERVED BY PULSE RADIOLYSIS. Bossy, Jean M. (Eidgenoessische Technische Hochschule, Zurich); Buehler, Rolf E.; Ebert, M. J. Amer. Chem. Soc.; 92: 1099-1101(25 Feb 1970).

Pulse radiolysis was used to study transient charge-transfer complexes in organic bromine compounds. Data are given on the complex formed in bromobenzene. (M.C.G.)

## Radiochemistry

*Refer also to abstracts 16610 and 16849.*

## Separation Processes

*Refer also to abstracts 16419, 16422, 16424, 16432, 16435, 16486, 16487, 16523, 16545, 16586, 16610, 17190, 17265, 18564, 18587, 18589, 18665, and 18692.*

16618 (CEA-CONF-1400) RECOMMENDATIONS CONCERNING LIXIVIATION TESTS IN WATER OF RADIOACTIVE SOLID WASTE FOLLOWING A CLASSICAL METHOD OF CONDITIONING. Lefillatre, G. (Commissariat a l'Energie Atomique, Chusclan (France). Centre de Production de Plutonium de Marcoule). July 15, 1969. 9p. (In French). (CONF-690822-1). Dep. CFSTI (U. S. Sales Only).

From Meeting of Experts on the Tests of Percolation of Mixture of Solids in which Radioactive Wastes are Incorporated, Vienna, Austria.

Leaching tests in water of radioactive solidified wastes made by various investigators are reviewed. The analysis led to the recommendation that leaching tests be made with periodic renewal of the leaching water. The advantages to be gained by this method are summarized with the only disadvantage—that of corrosion—preventable by taking certain precautions during the draining of the plastic flask. The periodicity of the renewal of the leaching water would depend on the leaching rate measured for each type of waste. An expression is derived for the results of the leaching rate. (J.S.R.)

16619 (CONF-681219-4) REPROCESSING OF IRRADIATED FUELS. Zifferero, M. (Comitato Nazionale per l'Energia Nucleare [Rome (Italy)]). [1968]. 50p. (In Italian). Dep. CFSTI (U. S. Sales Only).

From 10th International Nuclear Energy Conference, Milan, Italy.

Some of the technical and economic aspects of the reprocessing of irradiated fuel are analyzed with respect to the problems encountered in the reprocessing of fuel from Italian reactors. The general factors to be considered in the reprocessing of any nuclear fuel are first outlined. The processing costs, excess installed capacity, and the significance of the present European and American process charges are analyzed. The concept of the reprocessing plant is considered. The reprocessing characteristics are outlined. Dimensions of the plant, unit costs, and large reprocessing installations are considered. Safeguards and controls for processing plants of all sizes are discussed. The integration of transport into the processing system is considered. The present situation with respect to supply and demand in the United States, Europe, and Italy is described. The future problem of fast reactors is briefly discussed. (J.S.R.)

16620 (DOCKET-50201-30) [WEST VALLEY REPROCESSING PLANT]. Description of the New Off-Gas Treatment Cell. (Nuclear Fuel Services, Inc., West Valley, N. Y.). 4 Mar 1970. 27p. Dep. CFSTI.

The off-gas treatment cell proposed for the West Valley Processing Plant is described. Revisions to the Safety Analysis Report are also included. (M.C.G.)

16621 (DOCKET-50201-31) [WEST VALLEY REPROCESSING PLANT]. [Final] Safety Analysis Report, Revision 5. (Nuclear Fuel Services, Inc., West Valley, N. Y.). 4 Mar 1970. 22p. Dep. CFSTI.

Seismology, tornadoes, and a quality assurance program are considered in these revisions to the Safety Analysis report for construction of new facilities at the West Valley Processing Plant. (M.C.G.)

16622 (DOCKET-50332-6) BARNWELL NUCLEAR FUEL PLANT. Addendum No. 1 to Safety Analysis Report. (Allied Chemical Nuclear Products, Inc., Florham Park, N. J.). 27 Feb 1970. 174p. Dep. CFSTI.

Responses to questions on safety to support the application for a construction permit and operating license are given. (M.C.G.)

16623 (IS-2100, Sect. CE) CHEMICAL ENGINEERING DIVISION. Hansen, Robert S.; Burnet, G.; Burkhart, L. E.; Shuck, F. O.; Smutz, M.; Stevenson, F. D. (Ames Lab., Iowa). 8p.

The use of bis(2-ethylhexyl) phosphate (D2EHPA) as a solvent for separating rare earths was studied. Work is continuing on studies on the wetting characteristics of liquid metals and corrosion in liquid metals. Tests confirmed the effectiveness of Zr as a corrosion inhibitor for the Pb–Bi eutectic when in contact with 2¼% Cr–1% Mo alloy steel at 500 to 800°C. Results of measurements of diffusion coefficients for the Bi–Sm, In–Hg, and Cd–In systems as a function of composition are reported. Studies on thermodynamic properties by Langmuir vaporization were continued. (J.G.B.)

16624 (KFK-862) CENTRIFUGAL EXTRACTOR FOR THE REPROCESSING OF NUCLEAR FUELS WITH HIGH BURNUP AND PLUTONIUM CONTENT. Roth, B. F. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Heisse Chemie). May 1969. 45p. (In German). Dep. CFSTI (U. S. Sales Only).

The reprocessing of nuclear fuels with high burnup and high plutonium content presents difficult technical problems that can be solved by the introduction of centrifugal extractors, in which the contact time between organic and aqueous phases is only 4 to 10 sec in comparison with the 2-min contact time in a mixer-settler extractor of the same capacity. The principle, construction, and operation of a typical compact extractor stage of a centrifugal extractor is described. The geometrically safe extractor has a rotor diameter of 8 cm, a maximum total throughput of 14 l/min, and a contact time of 4 sec/stage. The principles for the calculation of the extractor are given. The maximum throughput and the material exchange efficiency were determined for three and six stages. The operational behavior of the centrifugal extractor was described. Possible uses of such an extractor are discussed. (J.S.R.)

16625 (ORNL-4449, pp 214-47) MOLTEN-SALT PROCESSING AND PREPARATION. Whatley, M. E. (Oak Ridge National Lab., Tenn.).

Topics covered include: measurement of distribution coefficients in molten salt–metal systems, flowsheet analysis, engineering development of process operations, distillation of MSRE fuel carrier salt, and design studies for salt processing. (M.C.G.)

16626 (SRO-344-4) REPROCESSING OF NPR FUEL AT NUCLEAR FUEL SERVICES, INC., WEST VALLEY FACILITY. (Savannah River Operations Office (AEC), Aiken, S. C.). Feb 1970. Contract AT(38-1)-344. 94p. Dep. CFSTI.

The first five months of reprocessing experience at Nuclear Fuel Services, (NFS), is summarized, and specific data relative to processing operations, analytical laboratory operations, and nuclear materials accountability are included. (P.C.H.)

16627 (UJV-2283-Ch) REGENERATION OF IRRADIATED NUCLEAR FUEL FROM VVR-S REACTOR BY EXTRACTION WITH 30 PERCENT TRIBUTYL PHOSPHATE IN N-DODECANE 1st EXTRACTION CYCLE. Sraier, Vratislav; Pavasovic, Vladeta; Talas, Miroslav; (and others) (Ceskoslovenska Akademie Ved, Rez. Ustav Jaderneho Vyzkumu). Nov 1969. 69p. (IBK-841). Dep. CFSTI (U. S. Sales Only).

Rods of nuclear elements EK-10 irradiated up to 6000 MWd/ton were cut and dissolved, and the resulting solution was used in three experiments to explore the first cycle in the reprocessing of nuclear fuel by extraction with 30% tributyl phosphate in n-dodecane. The purification of U and Pu from fission products was studied as well as the reduction separation of U from Pu using U(IV) and Fe(II) solutions as reducing agents and the re-extraction of U according to a modified scheme of the Purex process. The extraction equipment consisted of three 16-stage laboratory mixer-settlers placed in two glove boxes (the box containing the first extractor was shielded by 10-cm-thick Pb bricks). A special device for the preparation of samples for radiometry and chemical analyses afforded a possibility of handling the samples indirectly. Purification of U and Pu from the fission products was sufficient, while the separation of U from Pu need be still improved. Also, the losses of Pu into the high active waste need be reduced. (auth)

16628 SEPARATION OF THE RARE EARTHS BY CHROMATOGRAPHY ON ION EXCHANGERS. I. TECHNIQUE OF BUFFER ELUTION. Brunisholz, G.; Roulet, R. (Univ., Lausanne, Switzerland). Helv. Chim. Acta; 52: 1847-53(31 Oct 1969). (In French).

A displacement chromatography technique is described for the

separation of rare earths using the eluent ethylenediaminetetraacetate buffered by ammonium acetate to give a certain pH in the separation column. This method gives concentrations up to 20 g pure rare earth oxides per liter of eluate. In the technique described the heavy elements Eb and Lu pass into the effluent during charging with the initial mixture. Separation of the elements from La to Gd occurs by displacement chromatography. In contrast, the elements from Tb to Ho, including Y, are separated by elution chromatography; $[Zn(EDTA)]^{2-}$, forming at the Gd level then acts as the eluting agent. (BBB)

**16629** FIRST 200 GRAMS OF Pu EXTRACTED IN JAPAN: JAERI'S REPROCESSING TEST PROJECT. I. Aochi, Tetsuo (Japan Atomic Energy Research Inst., Tokai). Genshiryoku Kogyo; 15: No. 11, 45-8(Nov 1969). (In Japanese).

The developments by JAERI for the reprocessing of fuels have been the result of much research and many alterations. After design and construction of the facilities and preliminary testing, the reprocessing test was carried out 3 times in a 1-year period from January 1968 with spent fuel from JRR-3. JAERI was successful in extracting 200 g of Pu. The procedure employed is the improved high-acid Purex process employing two cycles; one with extraction with TBP and the other an ion exchange process for Pu. (TSS)

**16630** APPARATUS AND METHOD FOR SEPARATING A LIQUID FROM SOLID SUBSTANCES CONTAINED THERIN. Baumann, Gustav; Hentschel, Gerhard (to Brown, Boveri and Co. Ltd.). British Patent 1,180,020. 4 Feb 1970. Priority date 20 Dec 1966, Switzerland.

A method and apparatus for separating a liquid from a solid contained in the liquid and storing the solid consists of feeding the liquid containing the solid to a closed container made up of a filter inside the container with a space defined between the filter and the container walls. The filtered liquid is removed from the space and a liquid binding and/or radiation absorbing material is fed into the space. Finally the container with the solid is sealed. Centrifugation may be used to aid filtration. (B.L.M.)

**16631** EXTRACTION OF SCANDIUM FROM DIFFERENT MEDIA USING BIS(2-ETHYLHEXYL) PHOSPHATE. Csoevary, Mihaly; Czegledi, Bela; Kuzin, Ivan Andrejevics. Magy. Kem. Lapja; 24: 596-602(Dec 1969). (In Hungarian).

Studies were made on the extraction of scandium from different media with bis(2-ethylhexyl) phosphate dissolved in kerosene. The mechanism of extraction was studied and the value of the extraction constant determined. The effects of some anions and cations on the distribution ratio of scandium has also been studied. Data are presented on the extraction of scandium from different industrial liquids. (auth)

**16632** STUDIES ON REVERSED-PHASE PARTITION THIN-LAYER CHROMATOGRAPHY OF RARE EARTH ELEMENTS. Chang, Tiao-hsu; Chow, Tsan-lun (National Taiwan Univ., Taipei). Hua Hsueh; No. 1-2, 18-26(Jun 1969). (In Chinese).

Various methods for extraction of U, Th, and rare earth metal ions are considered, especially reversed-phase partition chromatography and liquid–liquid extraction. The use of the neutral organophosphorus compounds bis(2-ethylhexyl) phosphate (HDEHP), dibutyl phosphate (DBP), and tributyl phosphate (TBP) as organic phase in the reversed-phase partition thin-layer chromatography of rare earth nitrates, chlorides, and perchlorates was investigated. The $R_f$ and $R_M$ values are reported as a function of the acid concentration of the mobile phase for the movement of rare earth metal ions on thin-layers of silica gel, cellulose powder, or $Al_2O_3$ impregnated with HDEHP, DBP, or TBP. The effects of inert support structure and concentration of organophosphorus compounds, variations in the amounts of rare earth compounds used, various concentration of different mineral acids, as well as change of temperature are discussed. (BBB)

**16633** EXTRACTION OF URANIUM ($U^{VI}$) WITH METHYL PROPYL KETONE. Sarma, B. Labdev (Kanpur); 6: No. 1, 29-30(1968).

Methyl propyl ketone extracts U(VI) from $HNO_3$ with more than 65% of the U extracted with a single operation. The optimum concentration of the acid phase is 5N. Ammonium nitrate had almost no effect as a salting-out agent on the extraction. (Indian Sci. Abstr.)

**16634** METHOD FOR REMOVING RADIOACTIVITY FROM MILK. Nozaki, Hiroshi (to Japan Dairy Technical Association). Japanese Patent 1969-21386. 12 Sep 1969. Filed 25 Mar 1963.

A method is described for removing $^{89}Sr$ and $^{134}Cs$ from milk by ion exchange. The milk is passed through an ion-exchange tower made up of a strongly-acidic cation exchange resin of the mixed-salt type and a weakly-acidic cation exchange resin of the mixed free acid and salt type at a mixing ratio of 1:0.2. The resin is regenerated by a mixture of mineral acid and mixed salts. (NSA of Japan)

**16635** EXTRACTABILITY OF SOME METAL IONS WITH DIETHYLAMMONIUM DIETHYLDITHIOCARBAMIDATE–CHLOROFORM AND THE REEXTRACTABILITY OF THE COMPLEXES DISSOLVED IN CHLOROFORM. Foerster, H. (Forschungsinstitut fuer Nichteisenmetalle, Freiburg i. B.). J. Radioanal. Chem.; 4: 1-12(Jan 1970). (In German).

A description is given of the extractability of a large number of metal ions in the form of carbamidates from nitrate solutions, the reextractability of chelates dissolved in chloroform by various reagents and a few possibilities of separating metal ions by alternating extraction and reextraction. For extraction, a 1% solution of DDDC in chloroform, and for reextraction, acid, basic, cyanic, sulfide, fluoride, iodide, tartrate, complexon and other solutions have been used. Distribution ratios for a large number of systems are given, and possibilities of separating a number of metal ions are described. (auth)

**16636** SEPARATION OF TRACES OF SILVER FROM PALLADIUM BY A SURFACE REPLACEMENT REACTION. Miller, J. (Inst. of Isotopes, Budapest). J. Radioanal. Chem.; 4: 53-61 (Jan 1970).

An effective method has been developed for the enrichment of silver traces in palladium and of carrier-free $^{111}Ag$ formed in it by thermal neutron capture and subsequent $\beta$-decay. A replacement reaction occurring between hydrogen atoms absorbed in metallic palladium and cations in aqueous solution has been observed. A new device is proposed for the measurement of hydrogen absorbed by finely divided palladium without the necessity of removing it from the metal. Both palladium and silver ions were quantitatively and selectively deposited in the presence of other cations from hydrochloric acid solutions, whereas the deposition proved to be selective and quantitative for silver from ammoniacal solutions. About 0.4 ppM silver in specpure palladium can be removed by this method. A practical example of a more than 500-fold enrichment of silver traces in palladium is described. (auth)

**16637** CARRIER-FREE SEPARATION OF $^{228}Ac$ FROM AGED THORIUM NITRATE. Sani, A. R. (Atomic Energy Centre, Lahore). J. Radioanal. Chem.; 4: 127-9(Jan 1970).

A method is described for the separation of $^{228}Ac$ from aged thorium nitrate based on the use of a cupferron–chloroform mixture as an extractant. The radiochemical purity of the isotope was ascertained by following its decay over several half-lives. A series of decay curves obtained in this manner indicated half-life values in the range of 6.10 to 6.15 hr. It was also observed that unless a freshly prepared solution of cupferron is used, a good and clean separation cannot be achieved. (P.C.H.)

**16638** MILKING OF CARRIER-FREE $^{113m}In$ FROM $^{113}Sn$ BY VACUUM EVAPORATION TECHNIQUE. Palkar, V. R.; Rane, A. T. (Tata Inst. of Fundamental Research, Bombay). J. Radioanal. Chem.; 4: 131-5(Jan 1970).

The separation of carrier-free $^{113m}In$ from $^{113}Sn$ by fractional volatilization is described. In order to ascertain the exact evaporation conditions of In and Sb, a detailed preliminary study was made using $^{114m}In$ (T = 50 d) and $^{124}Sb$ (T = 60.3 d) tracers in metallic form. The evaporation of Sb between 600 and 650°C compared with In which just begins to volatilize at 630°C enabled the complete removal of $^{125}Sb$ first and then $^{113m}In$ was milked. The milking of $^{113m}In$ can be carried out in two ways so as to eliminate cross-contamination due to $^{125}Sb$. These methods are described. The method is both rapid and simple. A further advantage is that the separation and deposition of the sources, in a form suitable for electron spectrometer studies, are achieved in a single operation. (P.C.H.)

**16639** SEPARATION OF ZIRCONIUM AND HAFNIUM BY ADSORPTION ON SILICA GEL FROM HYDROCHLORIC ACID SOLUTIONS. Tsaletka, R.; Zaitseva, T. D. (Joint Inst. for Nuclear Research, Dubna, USSR). Zh. Anal. Khim.; 25: 82-6 (Jan 1970). (In Russian).

A method is suggested for the separation of micro- and macro-amounts of zirconium and hafnium and for their separation from other elements on the basis of the data on zirconium and hafnium adsorption on silica gel from hydrochloric acid solutions under statical conditions. The most suitable materials for complete separation are the coarsely porous kinds of silica gel, the optimum concentrations of hydrochloric acid are 7 and 11 M. The order of eluting the elements is changed by changing the acid concentration. The separation is more complete when mixed aqueous-organic solutions are used, at the same time this favors the purification of zirconium and hafnium from a number of other elements. (auth)

**16640** USE OF A CAE 510 COMPUTER AT THE PRODUCTION SERVICES OF THE LA HAGUE PLANT. Mimaud, R.; Degryse, M. (Services de Production de l'Usine, La Hague, France). Bull. Inform. Sci. Tech. (Paris); No. 143, 53-65(Dec 1969). (In French).

The Production Services of the La Hague Centre installed a CAE510 computer in the U.P.2 Plant, for studies of procedure and numerical regulation loops; general calculations of a scientific nature; and cataloging laboratory materials. The means employed and the results obtained are described. (auth)

**16641** COMPOSITION OF SOLVATES OF SCANDIUM CHLORIDE WITH TRIBUTYL PHOSPHATE (TBP). Korovin, S. S.; Berezhko, P. G.; Reznik, A. M.; Filatov, G. S. Izv. Vyssh. Ucheb. Zaved., Khim. Khim. Tekhnol.; 12: 1607-8(1969). (In Russian).

Studies were made on the mechanism of the extraction of Sc complex with TBP from HCl solutions by the methods of dilution, saturation, and ir spectroscopy. It was concluded that the complex compound of scandium chloride with TBP, $ScCl_3 \cdot 3TBP$, is formed in the organic phase. (TSS) (auth)

**16642** SOLVENT EXTRACTION STUDIES BY THE AKUFVE METHOD. IV. SPECTROPHOTOMETRIC DETERMINATION OF THE DISTRIBUTION OF ACETYLACETONE. Johansson, Hans; Rydberg, Jan (Chalmers Univ. of Tech., Goteborg). Acta Chem. Scand.; 23: 3797-2807(1969).

Using the AKUFVE method with spectrophotometric detection, the distribution of acetylacetone between different organic solvents and aqueous sodium perchlorate was investigated. It was found that the distribution constant ($k_d$) decreased with increasing ionic strength for the organic solvents benzene, toluene, xylene, mesitylene, ethyl benzene, and chloroform. At constant ionic strength, $k_d$ decreased with increasing number of methyl groups in substituted benzene. Furthermore, $k_d$ decreased with increasing temperature for the chloroform system, but remained nearly constant in the other systems. The results are discussed in relation to NMR measurements, and calculated $\Delta H$ and $\Delta S$ values. (auth)

**16643** SEPARATION OF COBALT FROM MIXTURES OF IRON RADIOISOTOPES BY MEANS OF EXTRACTION CHROMATOGRAPHY. Spevackova, V.; Krivanek, M. (Inst. of Nuclear Research, Rez, Czech.). Radiochem. Radioanal. Lett.; 3: 63-9(11 Feb 1970).

A method for the removal of $^{60}Co$ from a mixture of $^{59}Fe$ and $^{60}Co$ is described using dithizone adsorbed on a macroporous styrenevinylbenzene as agent in an extraction chromatographic column. $Co^{2+}$ forms a stable dithizonate but $Fe^{2+}$ does not react under the given conditions and can be quantitatively washed out. (auth)

**16644** SEPARATION OF THE LANTHANUM GROUP RARE EARTHS BY CONTINUOUS ELUTION WITH pH AND CONCENTRATION GRADIENTS IN A LACTIC ACID SOLUTION. De Bruyne, P. (Braine l'Alleud, Belgium). J. Inorg. Nucl. Chem.; 32: 3348-50(Jan 1970). (In French).

A description is given of the experimental technique adopted for the separation and identification of the rare earth fission product radioisotopes. The following separations were achieved; $^{91}Y$ and $^{93}Y$; $^{161}Tb$; $^{159}Gd$; $^{155}Eu$; $^{156}Eu$, $^{157}Eu$; $^{151}Sm$, $^{153}Sm$, $^{156}Sm$; $^{149}Pm$ and $^{151}Pm$; $^{147}Nd$; $^{141}Ce$, $^{143}Ce$, $^{144}Ce$; $^{143}Pr$. The results are discussed. (UK)

**16645** COMPARATIVE STUDY OF DONOR PROPERTIES OF SULPHOXIDES AND PHOSPHINE OXIDES IN SOLVENT EXTRACTION. Shanker, Ramendra; Venkateswarlu, K. S. (Bhabha Atomic Research Centre, Trombay, India). J. Inorg. Nucl. Chem.; 32: 229-37(Jan 1970).

It was believed earlier that the stretching frequency of the phosphoryl group could serve as a measure of its basicity. In sulfoxides, however, the S → O frequency in different sulfoxides is nearly constant and cannot be a guide to their donor properties. A new method of assessing the relative donor strengths of both phosphine oxides and sulfoxides is described, based on the shift of the symmetric stretching frequency of OH of water on coordination with the donor. It was found that both phosphine oxides and sulfoxides form a single group, whose solvent extraction properties are determined by their relative donor strengths, as determined by this procedure. The extractions of water, perchloric acid, hydrochloric acid, and pertechnetic acid by dibutyl sulfoxide (DBSO) are reported. The extracted species are $H_2O \cdot 2DBSO$ and $H_2O \cdot HClO_4$. (auth)

**16646** ISOTOPIC ENRICHMENT OF NEUTRON CAPTURE PRODUCT BY ELUTION FROM A FAUJASITE ZEOLITE. Campbell, D. O. (Oak Ridge National Lab., Tenn.). Inorg. Nucl. Chem. Lett.; 6: 103-9(Jan 1970).

A reaction that permits the direct separation and enrichment of the product of a neutron capture event from the target material was recently observed. This reaction and effect was demonstrated by separating the $^{142}Pr$ produced by neutron capture in naturally occurring $^{141}Pr$. Natural praseodymium ($^{141}Pr$) was loaded by ion exchange onto a faujasite zeolite (Linde X) and, following neutron irradiation, the neutron capture product (19.2-hr $^{142}Pr$) was found to be eluted preferentially. The eluate contained about 50% of the $^{142}Pr$ produced, and less than 1% of the $^{141}Pr$ present, thus indicating an enrichment factor of greater than 50. A similar reaction may be expected to occur in the instances of all the trivalent rare earths, the chemically similar trivalent actinides, and possibly other selected elements. (auth) (UK)

**16647** EXTRACTION OF YTTRIUM IN THE SYSTEM $YCl_3$–HCl–$H_2O$–DI(2-ETHYLHEXYL) PHOSPHORIC ACID. Harada, T.; Smutz, M. (Iowa State Univ., Ames). J. Inorg. Nucl. Chem.; 32: 649-62(Feb 1970).

The yttrium distribution coefficient E was determined for the system $YCl_3$–HCl–$H_2O$–D2EHPA in Amsco Odorless Mineral Solvent in the range of final aqueous concentration of yttrium = 0.0001 to 2.6 moles/l, final acidity H = 0.4 to 12 moles/l, and initial D2EHPA concentration $C_i$ = 0.3 to 2 moles/l. It was found that Peppard's simple ion exchange extraction reaction was followed exclusively only at low X and a limited range of H. A white precipitate of polymer $YG_3$, where $G = [C_4H_9CH(C_2H_5)CH_2]PO_4^-$, was observed in the organic phase at Y = 0.145 in the 1M solvent instead of 0.166 as anticipated. The variation of E with $H^+$ concentration was surprising. (auth) (UK)

**16648** NUCLEAR FUEL REPROCESSING IN THE FEDERAL REPUBLIC OF GERMANY. II. REPROCESSING OF URANIUM-THORIUM FUELS. Merz, E. (Kernforschungsanlage, Juelich, Ger.). Atomkernenergie; 15: 23-5(1970). (In German). (CONF-690419-11).

From Reactor Meeting of the German Atomforum, Frankfurt am Main, Germany.

According to the present state of knowledge agnous processes have the greatest chance to be successful in the reprocessing of thorium-containing fuel elements. One of the three promising possibilities compared at present will be technically and economically realizable within a short time. In the future fluoride volatilization could replace the aqueous processes. (auth)

**16649** NUCLEAR FUEL REPROCESSING IN THE FEDERAL REPUBLIC OF GERMANY. I. REPROCESSING OF URANIUM-PLUTONIUM FUELS. Baumgaertner, F. (Kernforschungszentrum, Karlsruhe, Ger.). Atomkernenergie; 15: 19-22(1970).

An installation was opened for the processing of U–Pu fuels and studies for reprocessing of fast breeder fuels undertaken. A solvent extraction method, similar to the Purex Process, was used. (M.C.G.)

**16650** STUDIES ON THE CHEMICAL BEHAVIOR OF U(III). Suzuki, Shin; Sato, Akiko (Tohoku Univ., Sendai). Res. Rep. Lab. Nucl. Sci., Tohoku Univ.; 1: No. 2, 137-9(Dec 1968). (In Japanese).

The solvent extraction behavior of U(III) with bis(2-ethylhexyl) phosphate (HDEHP) was studied using $^{237}U$ as the tracer. The trivalent uranium was obtained by reduction with liquid zinc amalgam. Four different diluents, benzene, toluene, isopropyl ether, and cyclohexane, were used with HDEHP and the extraction ratio was nearly zero, 3%, 26%, and 72%, respectively. The extraction of trivalent uranium from HCl solution into the HDEHP–cyclohexane phase seemed to occur according to the reaction: $U^{3+} + 3(HDEHP)_2 \rightleftharpoons U[H(DEHP)_2]_3 + 3H^+$, which is equivalent to the case of HDEHP extraction of actinide and rare earth elements in trivalent state. (NSA of Japan)

**16651** INTERACTION OF CHELATING AGENTS WITH $^{203}Hg$, $^{115m}Cd$, AND $^{65}Zn$ BOUND TO PROTEIN. Sugiura, Yukio; Tanaka, Hisashi (Kyoto Univ.). Radioisotopes (Tokyo); 19: 7-12(Jan 1970).

The interaction of the chelating agents with the metal bound to protein was investigated by equilibrium dialysis. The chelating agents containing mercapto group such as penicillamine and N-acetylpenicillamine had remarkable effect on the removal of Hg bound to the thiol group of the protein. On the other hand in the case of Zn removal, EDTA and DTPA were more effective compared with chelating agents containing mercapto group, and a linear correlation was found between the % of Zn removed from the protein and formation constants of Zn chelates. The % of the removal of Cd correlated to the chelate formation constants in the chelating agents containing the mercapto group and in EDTA analogs, respectively. The order of the ease of metal removal in the proteins tested was myoglobin > serum albumin > hemoglobin, re-

gardless of the type of chelating agent. Moreover, the existence of the ternary complex as the intermediate complex in the removal of the meral from the protein was shown by gel-filtration. (auth)

**16652** URANIUM OXIDE FLUORINATION WITH FLUORINE AND FLUORINE INTERHALOGENS. Holmes, John T.; Vissers, Donald R.; Gabor, John D.; Knudsen, Irving E. (to U. S. Atomic Energy Commission). U. S. Patent 3,490,881. 20 Jan 1970.

Uranium oxides can be fluorinated to $UF_6$ with dilute $F_2$ and catalytic amounts of fluorine interhalogens at temperatures of about 200°C. The preferred interhalogen is $BrF_3$, and the reaction is carried out in a fluidized bed. The process is applicable to the reprocessing of spent fuel elements. (B.L.M.)

**16653** METHOD OF SEPARATING POLONIUM FROM IRRADIATED BISMUTH. Baltisberger, Richard J. (to U. S. Atomic Energy Commission). U. S. Patent 3,491,003. 20 Jan 1970.

Polonium is separated from irradiated Bi by melting the Bi–Po; adding a carrier, such as Te, Se, Ag, Au, or Hg; cooling the material to form a solid member; placing the member in an acid solution containing Bi; electrodepositing Bi on a member inserted in the solution; and effecting precipitation of the Po and carrier as a sludge. The Po is subsequently separated from the carrier, and the Bi electrodeposited is reclaimed for recirculation. (AEC)

**16654** DISTRIBUTION OF $UO_2$(II)–TTA CHELATE AND THE ADDUCT FORMATION WITH TBP. Kanno, Takuji; Suzuki, Nobuo (Tohoku Univ., Sendai). Res. Rep. Lab. Nucl. Sci., Tohoku Univ.; 1: No. 2, 133-6(Dec 1968). (In Japanese).

A definite correlation between the distribution coefficient of TTA and that of its chelate with divalent $UO_2$ ions in inert solvents was noted. In the cases of $CCl_4$, hexane, heptane, and cyclohexane the distribution ratio of U, $D_m$, increased to a constant value with decreasing uranyl concentrations. In heptane with uranyl concentrations of $f < 10^{-7}$M, the chelate shows normal behavior. With the addition of TBP the adduct was formed according to the reaction $UO_2A_{2\,org} + TBP_{org} \rightleftharpoons UO_2A_2 \cdot TBP_{org}$, and the apparent formation constants in the various solvents were determined by the distribution method. The adduct formation is similar to the adduct formation for other metal chelates, and the similarity of $K_s$ for the uranyl chelate and zinc chelate was confirmed. The variations of $K_s$ can be explained in activity terms. (NSA of Japan)

**16655** SYNERGIC AND ANTAGONISTIC EFFECTS IN THE EXTRACTION OF INORGANIC COMPOUNDS WITH A MIXTURE OF AMINES AND ORGANOPHOSPHORIC ACIDS. Deptula, C. (Inst. of Nuclear Research, Swierk, Poland). J. Inorg. Nucl. Chem.; 32: 277-89(Jan 1970).

It was found that synergic and antagonistic effects occur in the extraction of uranium(VI) with a mixture of amines and organophosphoric acids. The composition of the extracted compounds in these systems was determined and constitutional formulas are proposed. The mechanism of the synergic and antagonistic effects is explained. (auth) (UK)

**16656** ACIDIC ORGANOPHOSPHORUS EXTRACTANTS. XI. EXTRACTION OF STRONTIUM BY SOME DI-n-ALKYL PHOSPHORIC ACIDS. Sistkova, N. V.; Kolarik, Z.; Chotivka, V. (Nuclear Research Inst., Czechoslovak Academy of Sciences, Rez, Czech.). J. Inorg. Nucl. Chem.; 32: 637-47(Feb 1970).

The extraction of strontium by di-n-alkyl phosphoric acids was studied, where n-alkyl was butyl, amyl, hexyl and octyl. The extraction mechanism is discussed, the composition of the strontium complexes prevailing in the organic phase was determined, and the stability constants of the complexes of strontium with di-n-amyl phosphoric acid in the aqueous phase were computed. (auth) (UK)

**16657** OXIDATIVE TREATMENT OF URANIUM ORE PRIOR TO ACID LEACH. Sierzputowski, Adam E. U. S. Patent 3,488,162. 6 Jan 1970. Filed 20 Oct 1967.

Uranium is leached from its finely divided ores by the use of dilute, sulfuric acid to form soluble uranium sulfate. Additives such as sodium chlorate, manganese dioxide or ferric salts may be added to accelerate the process. Favorable results are achieved by the use of entrained oxygen in the presence of a base and preferably a surfactant together with thorough agitation. (Official Gazette)

**16658** DISTRIBUTION OF URANYL TTA CHELATE. Kanno, Takuji (Tohoku Univ., Sendai). Res. Rep. Lab. Nucl. Sci., Tohoku Univ.; 1: No. 1, 82-4(1968). (In Japanese).

To clarify the effect of organic solvents on the distribution of TTA and its chelate with $UO_2^{2+}$, the uranium was converted to $^{237}U$ by electron-beam irradiation, and after equilibration, the U in the two phases was determined by measurement of $\gamma$ activity. Uranium was found in the organic phase only as the chelate $UO_2A_2$. The relationship between the distribution coefficient of the reagent and its chelate is given by $\log D_M = n \log P_{HA} + C$, where $D_M$ is the distribution ratio of U at a certain pH in various solvents, $P_{HA}$ is the coefficient of the chelating reagent (TTA), and C is a constant. However, in some hydrocarbons, such as n-hexane, the relationship did not apply, probably due to saturation of the organic phase with hydrated $UO_2A_2$. (NSA of Japan)

**16659** EXTRACTION OF SCANDIUM FROM AQUEOUS SULFATE SOLUTIONS BY BIS(3,5,5-TRIMETHYLHEXYL)AMMONIUM SULFATE. Cattrall, R. W.; Slater, S. J. E. (La Trobe Univ., Victoria, Australia). Inorg. Chem.; 9: 598-602(Mar 1970).

The complex formed in the extraction of scandium from aqueous sulfate solutions by bis(3,5,5-trimethylhexyl)ammonium sulfate dissolved in chloroform was isolated from the organic phase and was found to have the stoichiometric formula $(R_2NH_2)_4ScOH(SO_4)_3$ where R is 3,5,5-trimethylhexyl. This complex was shown to be monomeric whereas the amine sulfate salt conforms to a monomer–dimer equilibrium over the concentration ranges studied. Equilibrium studies were carried out and are in agreement with the suggested stoichiometry for the complex providing that the monomer–dimer equilibrium of the amine sulfate in chloroform is taken into account. (auth)

**16660** THE EXTRACTION OF VANADIUM, MOLYBDENUM, AND TUNGSTEN WITH ALKALI METAL THIOCYANATES AND FURALDEHYDE. Spaccamela Marchetti, Elena; Cereti Mazza, Maria Teresa (Politecnico, Turin). Ann. Chim. (Rome); 59: 902-11(1969). (In Italian).

The extraction of V, Mo, and W by furaldehyde in the presence of alkali metal thiocyanate in acid solution was studied. The best conditions for the extraction were investigated and the distribution coefficients versus metals and alkali metal thiocyanate concentration was determined together with the formulas of the extracted complexes, which are $V(CNS)_3 \cdot 2$ furf; $H_2[MoO_2(CNS)_3] \cdot 1$ furf and $H_2[WO_2(CNS)_3] \cdot 1$ furf. In addition, on the basis of the different values of the distribution coefficients and by experimental tests it was possible to demonstrate that these three metals can be satisfactorily separated using the Craig apparatus. (auth)

**16661** THIN-LAYER CHROMATOGRAPHY OF METAL IONS USING A WEAKLY BASIC CELLULOSE ION EXCHANGER, DEAE. Ishida, Koji; Kuroda, Rokuro (Univ. of Chiba, Japan). Jap. Anal.; 19: 81-6(Jan 1970). (In Japanese).

The thin-layer chromatographic behavior of 47 metal ions on DEAE has been investigated in 12 different solvents. In methanol–nitric acid media $R_f$ values are given as a function of nitric acid concentration at a fixed solvent volume ratio (methanol–nitric acid, 20:1, v/v). Many separations of metals are possible by proper selection of the concentration of nitric acid. In other systems (organic solvent–8M nitric acid, 20:1, v/v) only a few metals advance upwards and many others remain at the start, so that these systems are useful for the separation of particular metal ions. Thus, isopropanol is specific for Se(IV) and Re(VII), n-butanol and isobutanol for Au and Se(IV), acetone and ethyl acetate for Au and Sb(III), dioxane for Sb(III), ethyl ether for Au, acetic acid for Fe(III) and Ge, and tetrahydrofuran for V(IV) and Au. Difference in $R_f$ values on DEAE and a plain crystalline cellulose Avicel in several solvents suggests the presence of ion exchange adsorption by a weakly basic anion exchanger DEAE even in methanol–nitric acid medium. (auth)

**16662** ADSORPTION BEHAVIOR OF URANIUM DISSOLVED IN SEAWATER ON SYNTHETIC ULTRAMARINE. Riedel, H. J. (Kernforschungsanlage, Juelich, Ger.). Kerntechnik; 12: 16-19 (Jan 1970). (In German and English).

Uranium dissolved in seawater as the tricarbonate complex is found in the oceans in a concentration of 3.3 μg/l, remarkably constant down to depths of at least 400 m. The total reserve is estimated at 4.16 Gt. The suitability of synthetic ultramarine as an ion exchanger for the extraction of this uranium was studied. A capacity for $UO_2^{2+}$ ions of 0.1 mval/g was found. The ion exchange with $Na^+$ ions freely mobile in the ultramarine lattice follows the law of mass action. The uptake of $UO_2^{2+}$ ions from the tricarbonate was found to be 0.03 mval/g after the pH of the seawater was adjusted to 5. (auth)

**16663** EXTRACTION OF PENTAVALENT PROTACTINIUM FROM A 3 M PERCHLORIC ACID MEDIUM BY BENZENE SOLUTIONS OF THENOYLTRIFLUOROACETONE AND HEXONE. Boulanger, Francoise (Faculte des Sciences, Orsay, France). Bull. Soc. Chim. Fr.; No. 12, 4601-2(Dec 1969). (In French).

Studies on the solvent extraction of $^{233}Pa(V)$ from a 3M $HClO_4$ medium using benzene solutions of 4,4,4-trifluoro-1-(2-thienyl)-

1,3-butanedione and 4-methyl-2-pentanone showed that there is no synergistic effect in the separation. The extraction of Pa(V) is the sum of two independent phenomena. (tr-auth)

**16664** SEPARATION OF LEAD ISOTOPES ON CATION EXCHANGE RESINS. Jardy, Alain; Rosset, Robert (Ecole Superieure de Physique et de Chimie, Paris). Bull. Soc. Chim. Fr.; No. 12, 4576-90(Dec 1969). (In French).

The separation of the lead isotopes $^{206}Pb$ and $^{208}Pb$ was studied using various exchange reactions between the $Pb^{2+}$ cation in a sulfonate type cation exchange resin (Dowex 50 W, × 12) and lead complexes in aqueous solution in equilibrium with the resin (acetate, nitrate, and some polyaminocarboxylate anions such as ethylene diamine tetraacetate, EDTA, nitriloacetate, NTA, 2-hydroxyethylethylenediamine triacetate, HEDTA, and diethylenetriamine pentaacetate DTPA). The heavy isotope $^{208}Pb$ gives the most stable complex in all cases; thus, the resin is enriched in the light $^{206}Pb$ isotope. The apparent equilibrium constant $\alpha^{208}_{206} = (^{206}Pb/^{208}Pb)_R/(^{206}Pb/^{208}Pb)$, was determined by direct frontal analysis and found to be very close to 1 for acetate and nitrate complexes ($\alpha - 1 < 10^{-4}$), and 1 000 47 with NTA, for a complex concentration of $2 \times 10^{-2}$ M and a Na/complex ratio equal to 1. The unfavorable influence of sodium ion lead elution was demonstrated. $Na^+$ is unavoidably associated with the anionic complex considered. Data are less favorable with HEDTA ($\alpha$ = 1 000 26) whose molecular weight is higher than that of NTA. The EDTA and DTPA can not be used because of considerable lead elution (existence of a higher complex 2:1). The exchange between the dissolved cation $Pb^{2+}$ and the lead complex with the functional groups of aminodiacetate resin (Dowex A-1) was studied. Again, the heavier isotope $^{208}Pb$ gives the more stable complex, but the exchanges between resin and solution take place so slowly that precise measurement of the corresponding isotopic effect is impossible. General indications are given on the choice of complexing agents for separating metal isotopes with cation exchange resins. (auth)

**16665** MOLYBDENUM RECOVERY FROM WASTE ETCHING SOLUTIONS. Wlodyka, Jerzy; Przybyslawski, Adam; Jakubowski, Zygmunt. Rudy Metale Niezelaz.; 14: 636-9(Nov 1969). (In Polish).

The recovery of molybdenum from waste etching solutions, containing 90 to 95 g/l Mo, 200 to 300 g/l $HNO_3$, and 300 to 600 g/l $H_2SO_4$, was investigated. On the basis of normal and large scale laboratory tests it was found that the most convenient method of molybdenum recovery consisted in neutralizing the solution with ammonia liquor, pre-thickening through vaporizing, and subsequent crystallization of the neutralized solution. The precipitated crystals were filtered, dried, and calcined. In this manner, concentrates containing 90% $MoO_3$ can be produced, giving a high molybdenum recovery. (auth)

**16666** GENERAL SURVEY OF REPROCESSING OF THERMAL REACTOR FUELS. Ferguson, Don E.; Blanco, R. E. (Oak Ridge National Lab., Tenn.). pp 245-64 of The International Conference on Constructive Uses of Atomic Energy. /Farmakes, Ruth (ed.). Hinsdale, Ill.; American Nuclear Society (1969).

From International Conference on the Constructive Uses of Atomic Energy, Washington, D. C. See CONF-681101.

A description is given of the current state of processing technology for light-water reactor (LWR) fuels as applied at the Nuclear Fuel Services Plant (NFS) at West Valley, New York. Comments on the planned new processing plants and a summary of some current US research and development programs that apply to thermal reactors are also included. (P.C.H.)

**16667** RECENT FRENCH EXPERIENCE IN REPROCESSING. Sousselier, Y.; Jouannaud, C.; Delange, M.; Couture, J. (Commissariat a l'Energie Atomique, Fontenay-aux-Roses, France). pp 265-74 of The International Conference on Constructive Uses of Atomic Energy. /Farmakes, Ruth (ed.). Hinsdale, Ill.; American Nuclear Society (1969).

From International Conference on the Constructive Uses of Atomic Energy, Washington, D. C. See CONF-681101.

Studies were made on the experience gained in the field of new installations or process modifications, to provide some information on matters of chemical engineering and maintenance, to give an account of recent progress made in the field of effluent processing and measurements, and also to draw some conclusions regarding the economics of reprocessing and the philosophy of this operation. It was concluded that reprocessing has now come of age and that the existing plants, which are not being used at full load, will be able, for a long time to come, to carry out their task whatever the new features of the fuel elements they will be called upon to reprocess. (P.C.H.)

**16668** RECENT EUROCHEMIC REPROCESSING EXPERIENCES. Detilleux, E.; Cao, S. (EUROCHEMIC, Mol, Belg.). pp 275-87 of The International Conference on Constructive Uses of Atomic Energy. /Farmakes, Ruth (ed.). Hinsdale, Ill.; American Nuclear Society (1969).

From International Conference on the Constructive Uses of Atomic Energy, Washington, D. C. See CONF-681101.

A review of experience gained at EUROCHEMIC during the first two years of operation showed that the plant is fulfilling the aims assigned by the promoters of the Company: to offer reprocessing capacity; and to build up a know-how. In addition, the third aim of EUROCHEMIC has also been fulfilled: the training of specialists. The extraction processes and equipment used at EUROCHEMIC are described. (P.C.H.)

**16669** RECENT ITALIAN REPROCESSING EXPERIENCES. Calleri, Giacomo; Orsenigo, Giuseppe (Comitato Nazionale per l'Energia Nucleare, Rome). pp 288-319 of The International Conference on Constructive Uses of Atomic Energy. /Farmakes, Ruth (ed.). Hinsdale, Ill.; American Nuclear Society (1969).

From International Conference on the Constructive Uses of Atomic Energy, Washington, D. C. See CONF-681101.

The design and operation of the Eurex and ITREC plants for the reprocessing of reactor fuels are described. The destination of various types of fuels to one plant rather than to the other will be decided in accordance with the characteristics of the plants and the peculiarities of the fuel elements to be investigated with regard to the reprocessing procedures. (P.C.H.)

**16670** RADIOCHEMICAL SEPARATION OF GOLD BY AMALGAM EXCHANGE. Ruch, R. R. (Illinois State Geological Survey, Urbana). Anal. Chim. Acta; 49: 381-9(Mar 1970).

A rapid and simple method is described for the radiochemical separation of gold after neutron-activation. The technique is based on treatment with a dilute indium-gold amalgam, both chemical reduction and isotopic exchange being involved. The counting efficiency for $^{198}Au$ in small volumes of the amalgam is good. Few interferences occur and the method is applicable to clays, rocks, salts, and metals. The possibility of determining silver, platinum, and palladium by a similar method is mentioned. (auth)

**16671** FORMATION CONSTANTS OF EUROPIUM(III)-SALICYLATE COMPLEXES AND THEIR EXTRACTION INTO ISOAMYL ALCOHOL. Irving, H. M. N. H.; Sinha, S. P. (Univ. of Leeds, Eng.). Anal. Chim. Acta; 49: 449-54(Mar 1970).

The distribution of salicylic acid ($H_2Sal$) between isoamyl alcohol and aqueous buffers of constant ionic strength ($\mu$ = 0.1 M $NaClO_4$) was investigated over a range of pH values. The partition coefficient was found to be 109.3 and sodium salicylate was also found to be extracted to a small extent. The liquid-liquid extraction of europium(III) as its salicylate into isoamyl alcohol was investigated radiometrically. The partition coefficient log $p_c$ = 1.8(0) and the successive stability constants, $K_1 = 10^{2.59}$, $K_2 = 10^{1.62}$ and $K_3 = 10^{0.65}$, were evaluated. (auth)

# EARTH SCIENCES

## Geology and Hydrology

*Refer also to abstracts 16413, 16618, 16701, 16729, 16730, 16802, 16909, and 16910.*

**16672** (NVO-38-21) ANALYSIS OF 72-INCH HOLE DRILLING AT PAHUTE MESA. Bruesch, Grant T. (Fenix and Scisson, Inc., Mercury, Nev. Petroleum Consultants, Houston, Tex.). Oct 1969. Contract AT(26-1)-38. 90p. Dep. CFSTI.

The influence of the geology and the drilling practices on Pahute Mesa penetration rates is investigated. Graphs of the primary factors for each hole are presented. It is concluded that the penetration rate, as usual, is determined by how well the drilling procedures deal with the problems that nature represents. Pahute Mesa problems include open fractures, friable zones, hard rock, and formation water. Some of the major recommendations are to increase the use of the vacuum circulating system, increase the weight on the bit, and modify the water injection practices while using the dual string. (auth)

**16673** (ORNL-tr-2278) STUDY OF NATURAL RADIOACTIVITY OF SEDIMENTS OF THE ATLANTIC LOIRE. I. MEASURING THE TURBIDITY BY NATURAL RADIOACTIVITY. II. STUDIES OF SEDIMENT DEPOSITS. Anguenot, F.; Courtois, G. Translated by S. J. Rimshaw (Oak Ridge National Lab., Tenn.), from report DR/SAR-S-69-16/FA/GC/JJ. 65p. Dep. CFSTI.

The Loire River between Le Pellerin and Saint-Nazaire was studied to establish a correlation between the activity of sediments in suspension and the turbidity which was studied at a fixed station at several flow points and variable depths over a complete tidal cycle. There is evidence of a time lag between the salinity and turbidity fronts. Thus, a dynamic study of the turbidity of a muddy swirl was carried out along with measurements of the activity of background sediments from the channel and outside of the channel. With knowledge of the probe characteristics, a dynamic detection of a muddy swirl was attempted at an estimated precision of 2 g/l after taking into account the imperfections of the measuring method. A study of the relation existing between the activity of bottom sediment in the channel and outside of the channel was made. A previous cruise showed a difference in activity between these two zones. In situ and laboratory measurements did not confirm this point. On taking into account that the measurement conditions were very much better than those of the first cruise, it is concluded that the difference in activity in the channel and outside the channel is very slight, or does not exist at all. (auth)

**16674** (RLO-1951-3) PART I. STUDIES ON THE APPLICATION OF RADIOISOTOPE TECHNIQUES IN STREAM POLLUTION PROBLEMS IN THE PULP AND PAPER INDUSTRY. PART II. PAPER MILL FIBER AND CHIP TAGGING AND TRACING TECHNIQUE. Final Report. Chatters, Roy M.; Peterson, Richard L.; Rice, Richard D. (Washington State Univ., Pullman. Radioisotopes and Radiations Lab.). Nov 1969. Contract AT(45-1)-1951. 40p. Dep. CFSTI.

A method was developed for the identification and tracing of one type of wood fiber in the presence of one or more other types of wood fibers. The method, which relies upon the application of radioisotope techniques, was designed for purposes of obtaining a better understanding of the potential sources of stream pollution in the pulp and paper industry and for reducing these possible sources of steam pollution by means of in-plant process control. The method eliminates those problems usually associated with in-plant handling of radioisotopes and concern over compliance with federal, state, and local regulations dealing with radioisotope disposal in public waterways. It permits the tagging of fibers and their subsequent tracing without the introduction of any radioactive material into the pulp and paper mill processing system, and involves treating a small sample of wood chips of fibers with a metallic salt, removal of excess additive, dispersion of the treated chips or pulp into the mill system at any desired point and subsequent collection of fiber samples downstream in the process lines and effluent streams. Neutron activation analysis techniques are utilized to ascertain the amount, if any, of treated fibers present in the collected samples. Of all the materials tested, iridium and lanthanum have been utilized most successfully in chip and fiber tracing work due to their favorable nuclear characteristics, their firm adherence to wood fibers and natural scarcity or total absence in wood fibers and mill processing lines. A series of in-plant experiments were conducted to determine such characteristics as the detectability of lanthanum and iridium treated fibers and chips when mixed with a greater mass of untreated chips or fibers, the effects of chemical processing additives and the physical environment upon the treated materials, and the flow of treated fibers through pulp and paper processing lines and into effluent streams. (auth)

**16675** (RT/PROT-(69)22) PRELIMINARY RESEARCH ON SEVERAL TYPES OF LITHOLOGY OF C.R.N. OF TRISAIA IN RELATION TO THE POSSIBILITY OF CONTAMINATION OF THE AQUIFER AND OF SURFACE WATER. Cassano, G.; Lenzi, G.; Marzocchi, A. (Comitato Nazionale per l'Energia Nucleare, Rome (Italy)). 6 May 1969. 21p. (In Italian). Dep. CFSTI (U. S. Sales Only).

The general geological condition of the C.R.N. Trisaia (CNEN) and of its environs is described; particularly the stratigraphy of a well placed in the Center designed to receive medium- and high-level solid radioactive wastes was studied. The geological survey of the rocks of the well and the technique for preliminary research on the sorption of fission products by some selected samples are described. The samples are as follows: bottom silt (of Sinni River), clay, sand, and pudding stone. The sieve grading analysis of the above samples is reported and some hypotheses of the sorptive properties of the rocks are made. (auth)

**16676** (UCRL-50783) PERMEABILITY INCREASES IN HARDHAT GRANODIORITE SAMPLES FRACTURED BY EXPLODING FOILS. Quong, R. (California Univ., Livermore. Lawrence Radiation Lab.). 31 Nov 1969. 10p. Dep. CFSTI.

A technique is described for generating shocks in sample materials by exploding foils. This technique has application in studying the shock-induced fractures that an underground nuclear explosion produces in the surrounding rock. In a series of tests with exploding foils, samples of Hardhat granodiorite were subjected to stresses ranging from about 2 to 10 kilobars, comparable to stresses a few cavity radii out from an underground nuclear explosion. Before being shocked the specimens had permeabilities less than $10^{-6}$ millidarcy. After the shock, matrix permeabilities as high as 0.5 millidarcy were measured. Although the permeability of these samples increased greatly as a result of the exporimental shocks, it is still several orders of magnitude below the permeabilities measured in in situ Hardhat granodiorite after the shot. The difference may reflect the fact that the in situ measurements include larger scale effects such as flow through preexisting cracks and through fractures opened by the explosion along preexisting fault planes, types of flow passages which are not present in the samples. On the basis of these tests the exploding foil technique is regarded as a promising method for investigating shock-induced fracturing of earth materials. (auth)

**16677** (UCRL-72164) INFLUENCE OF ENVIRONMENT ON THE INELASTIC BEHAVIOR OF ROCKS. Heard, Hugh C. (California Univ., Livermore. Lawrence Radiation Lab.). 12 Dec 1969. 15p. (CONF-700101-5). Dep. CFSTI.

From Meeting on Engineering with Nuclear Explosives, Las Vegas, Nev.

The mechanical response of earth materials are demonstrably dependent upon the environment during deformation as well as the physical properties of the rock masses themselves. Among the most important of these environmental parameters are mean pressure, pore fluid pressure, temperature, strain rate, and the relative magnitude of the intermediate principal stress ($\sigma_2$) compared to the maximum ($\sigma_1$) and minimum ($\sigma_3$) stresses. Important inherent properties of rocks include anisotropy, homogeneity, porosity, permeability, grain size, and mineral composition. Calculation of the response of rocks to a nearby nuclear detonation requires knowledge of the deviatoric stress-strain behavior as well as the resulting mechanisms of deformation: fracture or flow. For calculations beginning at times of the order of $10^{-3}$ sec after detonation, that is, when peak pressures are $\sim 10^6$ bars and lasting to $\sim 10^2$ sec when cavity pressures have decayed to $\sim 10^3$ bars, broad limitations may be imposed on the possible deformation environment. Here, mean pressures range from $10^6$ to $10^2$ bars, pore pressures from $10^6$ to 1 bar, temperatures from 1500° to 50°C, and strain rates from $10^6$ to $10^{-3}$ per sec; $\sigma_2$ may range in value from that of $\sigma_3$ on loading to that of $\sigma_1$ on unloading. Using present technology, it is virtually impossible to measure the mechanical behavior of rock materials under controlled conditions over much of the above range. This behavior must be largely inferred from data gathered at less extreme conditions. Quantitative data illustrating the effect of the deformation environment upon the strength and brittle-ductile behavior are presented for a suite of rocks of interest to the Plowshare program; among these are limestone, quartzite, granite, sandstone and oil-shale.

More limited results are also presented illustrating the effect of planar anisotropies as well as of grain size upon mechanical properties. The available data then may be used to infer the mechanical response of rocks at the more extreme conditions near a nuclear detonation. (auth)

**16678** (USGS–289-3) HYDRAULIC TESTING AND SAMPLING OF USBM-AEC COLORADO CORE HOLE 3, RIO BLANCO COUNTY, COLORADO. Oil Shale-6. Cordes, E. H. (Geological Survey, Denver, Colo.). Dec 1969. 42p. Dep. CFSTI.

On November 21, 1967, the U.S. Geological Survey, in cooperation with the U.S. Bureau of Mines and the U.S. Atomic Energy Commission, completed the hydraulic testing and sampling of USBM-AEC Colorado Core Hole 3 in Rio Blanco County, Colorado. This hole was drilled to explore the site for Project Bronco, a Plowshare experiment to study the feasibility of in situ retorting of oil shale after breaking the rock with a nuclear explosion. The hydraulic tests indicate the existence of a highly permeable water-bearing zone in the upper and middle parts of the Parachute Creek Member of the Green River Formation of Eocene age. The zone yielded water in excess of 2,700 cubic meters per day (500 gallon per minute). During geologic time and even today, natural groundwater circulation is believed to have dissolved the syngenetic salt deposits from a part of the oil shale formations leaving a highly permeable zone of interconnected vugs and breccia channels. Older rocks underlying the Parachute Creek Member are comparatively impermeable to water flow and yielded less than 16 cubic meters per day (30 gallons per minute) of highly saline (49,000 parts per million dissolved solids) fluid. Potential flooding of a rubble chimney is an important consideration for project feasibility and safety. A first approximation of the magnitude of flooding was calculated from the test data. (auth)

**16679** (USGS–474-61) EVALUATION OF STRESS INSTRUMENTATION FOR PROJECT PAYETTE. Abel, John F. Jr. (Geological Survey, Denver, Colo.). 1970. 58p. Dep. CFSTI.

A review was made of available in situ rock stress estimation techniques and instruments and their potential for use on Project Payette was evaluated. The rock stress estimation instruments available are classed as either high-elastic modulus or low-elastic modulus. This classification refers to the stiffness of the instrument relative to the rock in which it is to be placed. The advantages and disadvantages of each classification are described with reference to Project Payette. (auth)

**16680** (USGS–474-64) PRINCIPAL LINEAR FRACTURES RESULTING FROM NUCLEAR EXPLOSIONS IN PAHUTE MESA. Dickey, D. D.; Ellis, W. L. (Geological Survey, Denver, Colo.). 1970. Contract AT(29-2)-474. 5p. Dep. CFSTI.

Long fractures caused by contained underground nuclear explosions on Pahute Mesa coincide with previously mapped geologic structures. The geology and the explosion-produced fractures are shown on the same base map. (auth)

**16681** GEOCHRONOLOGY AND ISOTOPE GEOLOGY. Hayase, Ichikazu (Kyoto Univ.). Kozan Chishitsu; 19: No. 93, 61-5(Mar 1969). (In Japanese).

A formula is given for deriving Rb–Sr isochron ages. The method is of use in tracing the origin and metamorphism of certain rocks. For example, Rb–Sr datings of the Mitaki Granites gave discordant isochron ages of 428 ± 4 Myr from biotites and 288 ± 19 Myr from K-feldspars. On the other hand, in Rb–Sr age determinations on the gneissic rocks from the vicinity of Showa Station, Antarctica, two different age groups of 458 ± 10 Myr and 1,110 ± 100 Myr have been obtained from the biotites and K-feldspars, respectively. These discordant ages may be explained as indicating later metamorphic events and the preceeding metamorphic episodes on formation of the rock itself. There is no general rule in the Rb–Sr dating in which the biotite age is older than the K-feldspar age or vice versa. The Rb content of the rocks developing in Japan is, in general, extremely low in comparison with the Precambrian rocks found in the continental shields. This is a fundamental difference between the Precambrian rocks from the continental shields and the newly developing rocks in an orogenic belt. (NSA of Japan)

**16682** SOLUTION OF PROBLEMS OF THE THEORY OF NEUTRON-GAMMA LOGGING BY A MONTE CARLO METHOD. Dyad'kin, I. G.; Starikov, V. N.; Enikeyeva, F. Kh. Izv. Akad. Nauk SSSR, Fiz. Zemli; No. 5, 94-101(1969). (In Russian).

General investigations of Monte Carlo algorithms for mathematical models of neutron-gamma logging, and also the algorithms and some results of specific neutron-gamma logging problems accomplished on the Razden-3 and BESM-6 computers are described. The high information content of the results, short calculation time (4 hours on the BESM-6), possibility of taking into account the effect of all the main factors and bringing out that effect, all lead to the conclusion that the method of mathematical modeling can successfully compete with physical modeling; in some cases the mathematical modeling proves to be the only possible method (effects of dolomitization, invaded zones, inhomogeneity of geologic and physical parameters). (Geophys. Abstr.)

**16683** SOLUTION OF THE DIRECT PROBLEM OF NEUTRON GAMMA LOGGING BY A MONTE CARLO METHOD. Dyadkin, I. G.; Starikov, V. N.; Enikeeva, F. Kh. Neftegazov. Geol. Geofiz.; No. 10, 40-1(1968).

An algorithm is presented for solution of the direct problem of neutron–gamma logging by a Monte Carlo method. This algorithm takes into account the following features of borehole measurement: eccentricity of the instrument, salinity of the drilling mud and formation water, geometry of the instrument (filters and housing), presence of casing in the well, and invaded zone. Programs have been written for the Razdan–3 and BESM–6 computers using this algorithm; with the latter, the computation takes 10 minutes of machine time. (Geophys. Abstr.)

**16684** INVESTIGATION OF THE SHAPE OF THE ANOMALY OF GAMMA–GAMMA DENSITY LOGGING. Artsybashev, V. A.; Popov, E. P. Izv. Vyssh. Ucheb. Zaved., Geol. Razved.; No. 7, 118-22(1968). (In Russian).

Results are presented of calculations and experiments designed to establish the real shape of gamma–gamma density logging anomalies. The accuracy of an earlier-proposed approximation of the anomalies (1964) is also assessed. The principal difficulties in using the characteristic points of the anomalies for determining the contacts and thickness of formations are ascertained. In most cases the angular points at the main anomaly are very distinguished, and therefore those should be used. The angular points at the peak either are not brought out (if the sonde has an isotropic detector) or are not clear and are shifted relative to their ideal position. Considerable distortion is noted when the layer thickness is less than the sonde length. The good agreement of the limbs and area of the real anomalies with their trapeziform approximation is the basis for recommending as most accurate this method of interpreting density logs with preliminary plotting of idealized anomalies. (Geophys. Abstr.)

**16685** EFFECT OF ASH CONTENT OF COALS AND COMPOSITION OF THE ASH ON THE READINGS OF SELECTIVE GAMMA–GAMMA LOGGING. Gorin, A. Z.; Dunchenko, I. A. Priklad. Geofiz.; No. 53, 171-9(1968). (In Russian).

The possibilities of selective gamma–gamma logging for determining the ash content of coals are assessed. By means of calculations, relations are obtained between effective atomic number of the coal substance and ash content for different amounts and composition of mineral impurities. For a number of very typical mineral impurities in coal seams, the equilibrium spectrums of scattered gamma radiation are calculated, and the optimal region of the spectrum is chosen which will guarantee greatest differentiation of selective gamma–gamma logging curves on the basis of ash content. (Geophys. Abstr.)

**16686** POROSITY LOGGING EMPLOYING TWO THERMAL NEUTRON DETECTORS SPACED RELATIVELY FAR FROM NEUTRON SOURCE. Allen, Linus S. (to Mobil Oil Corp.). U. S. Patent 3,491,238. 20 Jan 1970. Filed 16 Aug. 1966.

The design is given of a technique and system for logging for porosity by employing two spaced-apart thermal neutron detectors, each located a relatively great distance from a neutron source. At large source-to-detector spacings, it has been found that the thermal neutron flux detected will have an epithermal neutron parameter, the slowing down length, which is greater than the thermal neutron parameter, the thermal neutron diffusion length. By taking the ratio of the thermal neutron flux detected by each of the spaced detectors, essentially all dependents of the thermal neutron measurement upon thermal neutron parameters can be eliminated or significantly reduced, thereby allowing measurements to be made predominantly of the epithermal neutron parameter with spaced thermal neutron detectors. (Offic. Gaz.)

**16687** ANALYTICAL–CHEMICAL DETERMINATION OF STRONTIUM AND RUBIDIUM FOR CALCULATION OF GEOLOGIC AGES. Molina Berbeyer, Rafael. Rev. Soc. Quim. Mex.; 12: 110A-12A(1968). (In Spanish).

An isotope dilution technique for Rb–Sr age determinations is described in which Rb is precipitated as the perchlorate and Sr is separated by ion exchange and evaporated to dryness. The solids are than applied to a tantalum filament for mass spectroscopy. The equations used and the special precautions required are discussed. (Geophys. Abstr.)

**16688** RADIOACTIVITY MEASUREMENT IN SOIL MECHANICS. Wack, Bernard. Bull. Dir. Etud. Rech., Ser. A; No. 2, 1-135(1969). (In French).

Thesis.

Systems comprising a sealed radioactive source, a radiation detector, and a soil sample (in a large mass of soil or by itself) are discussed. The general notions involved are briefly reviewed, and the special features of the use of this type of measurement method in soils are described, including: the additional advantages of gamma and neutron measurements to establish soil moisture content and dry density; the various possible measurement geometries; and the difficulty of calibrating measurements because of soil sample heterogeneity. Three particular applications discussed are: local density measurement of a pulverulent soil sample under a triaxial test load; laboratory measurement of soil moisture variations; and on-site moisture and density measurements applied to compaction control. By use of the attenuation of a beam of gamma radiation and by optical or photometric sample diameter measurement along a diameter or a chord the density of a sample has been successfully measured to within a relative accuracy of a few parts per thousand. It has been shown that sand has a critical density which varies with lateral pressure. The apparent density field and its variation with strain have also been determined. A new theoretical strain diagram is suggested. Gamma and thermal neutron transmission requirements are compared and it was found that, though theoretically more promising, the latter cannot be used very satisfactorily at present because of the low efficiency of thermal neutron sources. An experimental study of moisture measurement by high-energy neutron transmission has enabled compaction control equipment to be developed for site use, which measures dry density and moisture content by weight over a 30 cm thickness of soil. It has given most satisfactory results at the Mont Cenis dam site, which checked well with the results of conventional measurements. (auth)

**16689** DETERMINATION OF THE CLAY CONTENT OF ROCKS FROM DATA OF THE GAMMA METHOD AND SELF POTENTIALS. Kapkanshchikova, I. A. (Inst. of Geophysics, Kiev). Geofiz. Sb., Akad. Nauk Ukr. SSR, Inst. Geofiz.; No. 24, 46-50(1968). (In Russian).

The problem of qualitative determination of clay content of the Paleogenic rocks of the inner zone of the Carpathian foredeep is illustrated by the example of the Strutyn and Oikhovka areas, using results of collective interpretation of data obtained by the SP and natural gamma logging methods. (Geophys. Abstr.)

**16690** RADIOMETRIC METHOD FOR HYDROGEOLOGIC STRATIGRAPHY. Ochiai, Toshiro (Agricultural Engineering Research Station, Kanagawa, Japan). Chikasui To Ido To Ponpu; 11: No. 11, 6-14(Nov 1969). (In Japanese).

A radiometric method for determining three dimensional distribution and structure of aquifers has been tried in the Chojahara Plateau, Fukushima prefecture. The porosity of each aquifer in its natural condition can be measured by using a $\gamma-\gamma$ detector. The instrument used in this study consisted of a $\gamma$ source, lead shield, scintillation counter [$1\frac{1}{2}$"(13 m/m) × 2"(31 m/m) NaI crystal], cable drum, counting set, and recorder. $^{137}Cs$ (5 mCi) and $^{60}Co$ (0.5 mCi) were used as $\gamma$ source. Since the vertical variation of bulk density in some aquifers can be easily measured in succession by the $\gamma-\gamma$ detector, the porosity is calculated by the formula $P = [(G_s - G/G_s - G_w) \times 100]$; where P is the porosity (%), $G_s$ is the density of porous material (g/cc), G is the saturated bulk density with ground water measured by the $\gamma-\gamma$ detector (g/cc), and $G_w$ is the density of ground water in porous zones (g/cc). The obtained porosity ranges from 40 to 65% and is in close agreement with the determination by the dry method which was carried out on cores at the time of boring, with the error within 6%. This suggests that the radiometric method for analyzing hydrogeologic stratigraphy is very useful. (NSA of Japan)

**16691** ON ELIMINATING THE EFFECT OF MOISTURE CONTENT OF ROCKS FROM THE RESULTS OF MEASUREMENTS BY NEUTRON GEOPHYSICAL METHODS. Filippov, E. M. Geol. Geofiz.; No. 1, 115-21(1969). (In Russian).

On the basis of theoretical and experimental investigations it is shown that the ratio of the counting rates of thermal and epithermal neutrons for some ranges of moisture content of rocks is independent of variations in their water content i.e., that there is a so-called plateau in the instrument. A similar plateau is noted in measurements of the ratio of the counting rates of gamma-quanta in trapped radiation and of thermal neutrons. These ratios depend only on the content of certain elements in the rocks. (Geophys. Abstr.)

**16692** EVOLUTION OF ORGANIC MATTER IN THE SOIL: ITS DETERMINATION WITH NATURAL $^{14}C$. Ronzani, C. A. (Univ., Bonn). Acta Cient. Venez.; 19: 180-83(1968). (In Spanish).

A new type of application of the $^{14}C$ dating method is presented for the analysis of soils; pathways for mineralization are discussed. Three different types of soil were studied; from each of these six fractions were obtained: fulvic acids, humatomelanic acids, brown humic acids, grey humic acids, humins, and C-humus. The C was transformed into $C_6H_6$ by a four-step procedure, and the activity of the benzene then determined. The route involves oxidation of organic material to $CO_2$, reduction of $CO_2$ by Li to give $Li_2C_2$, hydrolysis of the carbide to acetylene, and trimerization of the acetylene. The results obtained were compared with observations of other workers on the genesis of soil materials, and a path for formation of various soil components is discussed. Improvements of the technique suggested are being pursued. (BBB)

**16693** ON THE PROBLEM OF THE USE OF RADIOACTIVITY OF GROUND WATERS AS AN INDIRECT HYDROCHEMICAL CRITERION OF OIL-BEARING CAPABILITY. Filonov, V. A. K. Neftegazov. Geol. Geofiz.; No. 3, 32-5(1969). (In Russian).

An investigation is reported of the radioactive elements in ground waters in the Devonian formations of the Pripyat basin, where the section contains two thick saline series which are impervious to water and to a considerable degree determine the hydrogeochemical character of the Devonian section. A correlation is found between an increase in salinity of the ground waters and an increase in radium content. The relationship observed between the variations of $Ra \times 10^{12}/M$ (the coefficient of relative radium saturation of the water) and of Ra/U is even more distinct. The numerical value of these relationships, however, is not the same as that in the Dnieper-Donets basin. Thus, to use the radioactivity coefficients of ground water as an indirect hydrochemical criterion for oil- or gas-bearing capabilities, it is necessary to choose a numerical reference value for each area on the basis of data from regional investigations, against which to match measured values. (Geophys. Abstr.)

**16694** RAPID CHANGES IN NITRITE AFTER GAMMA IRRADIATION OF FRESH SOILS. Cawse, P. A.; White, T. (Atomic Energy Research Establishment, Wantage, Eng.). J. Agr. Sci.; 73: 113-18(Aug 1969).

The rate and extent to which nitrite is formed, perhaps by reduction of nitrate, after irradiation of soils were studied and attempts made to correlate these findings with soil properties. Ten soil series were sampled from the top 6 in. at arable, grassland, and deciduous woodland sites. The samples were irradiated with a $^{60}Co$ source giving a dose rate of 0.9 Mrad/hr. Initially, the soils were exposed to doses between 0.25 and 2.5 Mrad, and incubated for 7 days at 25°C. Ammonium, nitrite, and nitrate were determined before irradiation after incubation. Maximum formation of nitrite in these soils in relation to dose always occurred in the 0.5- to 0.75-Mrad region, but nitrite concentration decreased as the radiation dose approached 2.5 Mrad. Formation of nitrite was radioresistant in the soils with most inorganic carbon, suggesting the presence of either greater numbers of nitrate-reducing organisms which allow more survivors after irradiation, or less radiosensitive organisms. There were large differences in the ability to oxidize radiation-released ammonium. It was concluded that nitrification in the irradiated soil is limited by the low activity of nitrifying organisms, rather than the extent of microbial damage and mineralization. Only the very acid series failed to produce nitrite, but formation and persistence was poor in all soils below pH 7. Leaching with ammonium or nitrate ions after irradiation suggested that microbial reduction of nitrate was the mechanism responsible for nitrite accumulation, rather than inhibition of nitrite oxidation. (BBB)

**16695** $^{90}Sr$ FALLOUT OVER LAKE MICHIGAN. Machta, L.; Telegadas, K.; Harris, D. L. (Environmental Science Services Administration, Silver Spring, Md.). J. Geophys. Res.; 75: 1092-6(20 Feb 1970).

Measurements of $^{90}Sr$ in Lake Michigan water and sediments indicate that fallout is no greater over the lake than over nearby land. Excess "oceanic" fallout over land fallout is in controversy. The Lake Michigan result favors no enhancement. (auth)

**16696** OCEAN FALLOUT: THE CRATER LAKE EXPERIMENT. Volchok, H. L. (Atomic Energy Commission, New York); Feiner, M.; Simpson, H. J.; Broecker, W. S.; Noshkin, V. E.; Bowen, V. T.; Willis, E. J. Geophys. Res.; 75: 1084-91(20 Feb 1970).

By the analysis of water and sediment cores, the total inventory of strontium-90 in Crater Lake, Oregon, was determined to be 4.2 Curies. In terms of surface fallout, this is equivalent to about 70 mCi/km$^2$. The comparable fallout on the surrounding land area, determined from analyses of soil sections was 58 mCi/km$^2$,

and a value predicted by extrapolation from other Oregon stations was 73 mCi/km$^2$. Hence, no substantial difference in the efficiency of fallout collection could be attributed to the mere presence of the large water surface. (auth)

16697 NEW MEASUREMENT OF THE RADON CONTENT OF THE WATERS AT BAD BRAMBACH. Herrmann, D. B. (Staatliche Zentrale fuer Strahlenschultz, Berlin). Arch. Phys. Ther., 20: 29-32(Jan.-Feb. 1968). (In German).

The mineral waters of Bad Brambach have been known for more than 150 years and used as drinking water. In 1911 a new spring was drilled which showed a very high value of radioactivity, $8.26 \times 10^{-7}$ Ci, due to its Rn content. Measurements made in 1935 showed good agreement with those of 1911. However, the lapse of time made it desirable to measure the constancy of Rn content by more accurate present day measuring methods. The design, operation, and accuracy of the measuring equipment and method are described. The results of measurements on water from four springs are tabulated and compared with those obtained in 1911 and 1935, and found to be remarkably similar. This is particularly true for the "Radon Spring" for which the respective data were $7.06 \times 10^{-7}$, $7.03 \times 10^{-7}$, and $7.04 \times 10^{-7}$ Ci. The long half-life of Ra guarantees a relatively stable Rn emanation and makes an observable decrease in Rn production very unlikely. (F.J.W.)

16698 HYDROLOGIC REDISTRIBUTION OF RADIONUCLIDES AROUND A NUCLEAR-EXCAVATED SEA-LEVEL CANAL. Charnell, R. L.; Zorich, T. M. (A. Teledyne Co., Palo Alto, Calif.). Bioscience; 19: 799-803(Sep 1969).

A brief discussion of the hydrologic redistribution of radionuclides deposited in the environment following nuclear excavation of a sea-level canal in Central America is presented. A simple yet comprehensive numerical model is presented by which estimates of the rates of removal of radionuclides from deposited fallout and from the ejecta and fallback can be made, as well as a diagrammatic model of the general hydrologic cycle is presented. The largest reservoir in the hydrologic cycle is the ocean-canal system where water is held in the form of a saline solution. Water leaves this reservoir by evaporation to lodge temporarily in the atmosphere and returns to the surface as precipitation. From the surface, water evaporates or satisfies soil moisture or vegetation requirements. Some of the water enters the groundwater system. Water returns to the ocean by runoff and flow from ground water. Volatile constituents travel all paths of the hydrologic cycle. Soluble radionuclides move with the water except during evaporation, but are retarded because of plant uptake and adsorption on soil and rock particles. The filtering action of soil and rock restricts the movement of particulate matter to surface water. Examination of the entire hydrologic redistribution regimen requires that the alteration of the hydrologic system be taken into account. The redistribution model can be applied to specific field conditions with the proper selection of values for the rate coefficients. (BBB)

16699 GEOLOGICAL SURVEY RESEARCH, 1969. CHAPTER A. Geological Survey Professional Paper 650-A. Washington, D. C.; U. S. Government Printing Office (1969). 434p, $4.00. (NP-18117).

A summary is given of scientifically and economically significant results of geological research completed in 1969 accompanied by a list of publications released in fiscal year 1969, a list of geologic and hydrologic investigations in progress, and a report on the status of topographic mapping. The research is categorized as resources investigations (geological, geophysical, mineral, and water), geologic and hydrologic principles, processes, and techniques, conservation and engineering uses of geologic and hydrologic research, astrogeology, and investigations in foreign countries. (L.C.L.)

## Meteorology

*Refer also to abstracts 16452, 16620, 16621, and 16802.*

16700 (ARLV-351-3) WEATHER PREDICTIONS AND SURFACE RADIATION ESTIMATES FOR THE MILROW EVENT. Final Report. Armstrong, Robert H.; Morrell, Joseph R. (Environmental Science Services Administration, Las Vegas, Nev. Air Resources Lab.). Dec 1969. Contract SF54-351. 49p. Dep. CFSTI.

For the MILROW Event, three surface wind towers were installed and instrumented on Amchitka Island. A 24-hour weather observing station, equipped to take upper-air soundings of wind, temperature, pressure, and humidity along with surface observations, was in operation at the Northwest Camp for two weeks preceding the event. Communication facilities for receiving large-scale meteorological data and forecasts for the North Pacific Ocean area from the major forecast centers were acquired. Weather forecasts for the Amchitka area were issued twice daily. Event-oriented forecasts of winds, weather, vertical atmospheric stability, and air trajectories were presented to the Test Manager and his Advisory Panel in daily formal and informal briefings beginning at D – 9 days. Recognizing the possible, though unlikely, release of radioactivity into the atmosphere, estimates of potential radiation effects were also presented during the briefings. Intensive surveillance of changing meteorological conditions at the surface and aloft throughout the western Aleutian Islands was maintained on D-Day by means of frequent weather observations at Shemya, Amchitka, and Adak. Meteorological interpretation of data from these observations starting with the final readiness briefing and continuing throughout the day was provided. D-Day meteorological data are included. (auth)

16701 (CEX-61.7.1) AERORADIOACTIVITY SURVEY AND AREAL GEOLOGY OF THE MINNEAPOLIS–SAINT PAUL AREA, MINNESOTA–WISCONSIN (ARMS-I). Neuschel, Sherman K. (Geological Survey, Washington, D. C. Division of Biology and Medicine (AEC), Washington, D. C.). Jul 1967. 24p. Dep. CFSTI.

An aeroradioactivity survey of approximately 10,000 square miles in the Minneapolis-Saint Paul area of Minnesota-Wisconsin was made. Radioactivity profiles were obtained using scintillation-detection equipment along parallel, mile-spaced, east-west flight lines approximately 500 feet above ground. A map of aeroradioactivity units compiled from the profiles shows generally low to moderate radioactivity varying from 50 to 550 counts per second. There is some correlation of radioactivity with the geology. The area is covered by a thick mantle (up to 500 feet) of glacial deposits mostly Wisconsin in age. There are exposures of bedrock in valleys of major streams and in a few places in the interstream areas. Low radioactivity, 50 to 250 cps, is found over alluvium and glacial outwash plains. Radioactivity over glacial drift is low to moderate, 250 to 450 cps. The few places where radioactivity is above 450 cps are associated with bedrock outcrops. (auth)

16702 (FOA-4-4406) CALCULATION OF SO-CALLED EFFECTIVE UPPER WINDS IN THE STRATA 0-8 km AND 0-14 km. Lindblom, G. (Forsvarets Forskningsanstalt, Stockholm (Sweden)). Dec 1969. 25p. Dep. CFSTI (U. S. Sales Only).

An investigation of the effects of a nuclear attack on Sweden and its environs requires a meteorological base for calculation of the extent of radioactive fallout. This is the first report on 7 years of wind probing at Bromma (ca. 5,300 measurements). (auth) (Sweden)

16703 (SC-RR-69-572) CLIMATOLOGY OF AIRBLAST PROPAGATIONS FROM NEVADA TEST SITE NUCLEAR AIRBURSTS. Reed, Jack W. (Sandia Labs., Albuquerque, N. Mex.). Dec 1969. 123p. Dep. CFSTI.

Microbarograph data from Nevada atmospheric nuclear tests of 1951 to 1962 have been assembled to show climatological patterns for long range propagations. Amplitudes have been normalized to 1-kiloton yield, free-airburst, after actual height-of-burst effects were removed. On-site propagations under early morning inversions often showed double the amplitudes expected for standard hemispherical wave expansion. These enhanced blasts were blocked by mountains and did not penetrate off-site. Strong winds at higher altitudes gave as much as 5× blast magnifications at Indian Springs and Las Vegas. Ducting at very high altitude, to 30 miles or 150,000 feet, is seasonally directed eastward in winter, westward in summer. Resulting amplitudes in the sound ring near 135 miles range show as large as 3× magnification downwind and 0.006× reduction upwind. On the average the annual cycling in east and west directions ranges from near standard, 1×, downwind amplitudes to 0.016× upwind amplitudes. The seasonal reversal periods when upper winds are nearly calm, occur about May 5 and September 20. At that time amplitudes in all directions show an average 0.28× reduction below standard. (auth)

16704 (SU-326-PA-16-3) $^{210}$Pb IN SURFACE AIR ALONG THE SLOPES OF MAUNA LOA VOLCANO, HAWAII. Final Report. Technical Report No. 117. Kruger, Paul (Stanford Univ., Calif. Dept. of Civil Engineering). Sep 1969. Contract AT(04-3)-326. 24p. Dep. CFSTI.

The massive volcano Mauna Loa affects the general circulation of the trade winds. The presence of the radionuclide $^{210}$Pb on aerosol particles has been a source of study of atmospheric chemical and transport processes. Lead-210 results from the successive decay of a series of short-lived radioactive products of $^{222}$Rn which diffuses into the atmosphere as an isotope of the rare-gas element radon. The comparatively large values of $^{210}$Pb concentration in Hawaii might indicate that little $^{210}$Pb is

removed from the atmosphere during the trade wind transport over the open ocean. Lead-210 and $^{90}Sr$ concentrations on aerosols were measured between July 17 to 20, 1966 and August 29 to September 1, 1967, in Hawaii, at 4 locations other than the volcano. Radon-222 concentrations were measured at the volcano and three other locations in Hawaii on August 30 and 31, 1967. (J.C.W.).

16705 $^{222}Rn$ IN THE NORTH ATLANTIC TRADE WINDS: ITS RELATIONSHIP TO DUST TRANSPORT FROM AFRICA. Prospero, Joseph M. (Univ. of Miami, Fla.); Carlson, Toby N. Science; 167: 974-7(13 Feb 1970).

The concentration of radon-222 in air was measured during a flight from Miami to Barbados to Dakar and return; concentrations ranged from 1 to 55 picocuries per standard cubic meter of air and were highest in areas of dense haze, which were present along most of the flight path across the Atlantic Ocean. The haze is attributed to dust originating from the arid regions of western Africa. Radon-222 may be useful as a tracer for African air parcels over the equatorial Atlantic. (auth)

16706 ON THE STOCHASTIC NATURE OF THE ACQUISITION OF ELECTRICAL CHARGE AND RADIOACTIVITY BY AEROSOL PARTICLES. Boisdron, Y.; Brock, J. R. (Univ. of Texas, Austin). Atmos. Environ.; 4: 35-50(Jan 1970).

The distributions of charge and radioactivity in an aerosol arising from the stochastic nature of the acquisition processes are discussed. Three illustrations are given. The electrical charge distribution resulting from the unipolar diffusion charging of a monodisperse aerosol is derived. The kinetics of the adsorption of radioactive iodine and RaA on a monodisperse aerosol and the resultant distribution of radioactivity are described. (auth) (UK)

16707 AIR CONTAMINATION OF KUR. Tujimoto, Tadashi; Negoro, Akihiko (Kyoto Univ.). Hoken Butsuri; 4: 575-80(Dec 1969). (In Japanese).

The air contamination caused by the operation of Kyoto University Research Reactor has been investigated. At a reactor power of 5000 kW, the radioactive gas production observed was about 160 $\mu$Ci/sec activated by the open beam tubes and also about 200 $\mu$Ci/sec by the primary coolant contamination, respectively. The production of radioactive dust was about 0.0003 $\mu$Ci/sec. Concentrations may be changed by the conditions of reactor room ventilation, primary coolant, and reactor power. (NSA of Japan)

16708 ON THE RADIOACTIVITY OF SUMMER CLOUDS ON MOUNT OLYMPUS. Danali, Susan D. (Democritos Nuclear Center, Athens). Pure Appl. Geophys.; 75: 263-7(1969/IV).

The radioactivity in different parts of a cloud as well as the radioactivity of the atmosphere before and after the cloud's passage are examined with stationary samplers — fallout pans, Grunow cloud-catchers of various materials, and air-pumps — at elevations of 1800 m and 2817 m, on Mt. Olympus, Greece. The relation between the cloud's density and its radioactivity is examined. (auth)

16709 MODELING OF ATMOSPHERIC DIFFUSION PROCESSES. Podlaha, Miroslav (Vyzkumny Ustav Energeticky, Prague). Energetika; 19: 489-92(Dec 1969). (In Czech).

The conditions and assumptions necessary for modeling atmospheric phenomena (described by the equation of atmospheric diffusion) at a reduced scale in a wind tunnel are defined. Tests showed that in modeling it is not necessary to strictly adhere to the Reynolds criterion, and that it is the Lambda criterion that is decisive in this case. The Lambda criterion stems from the equation for atmospheric diffusion which, in turn, also takes into account sources of contamination. (auth)

16710 EXPERIENCES WITH MEASUREMENTS OF RADIATION, TEMPERATURE GRADIENT, AND WIND AS DEFINING QUANTITIES OF DIFFUSION CATEGORIES. Polster, Gebhard (Kernforschungsanlage, Juelich, Ger.). Meteorol. Rundsch.; 22: 170-5(Nov-Dec 1969). (In German).

Evaluation of simple systems used for determining diffusion categories with respect to measured radiation, balance, temperature gradient, and wind, and for assessing the diffusion of radioactive elements in the lower atmosphere is described. The conditions of diffusion of these elements by advection and other dynamic atmospheric phenomena are established. The ability of simple systems to determine diffusion categories is checked, and the discrepancies are assessed. On the basis of measured radioactivity data, it is shown how the defining quantities are useful in solving difficult problems concerning the diffusion of radioactive elements and how improvements can be achieved. (IAA)

16711 GAMMA SPECTROMETRIC INVESTIGATION OF LASTING ARTIFICIAL RADIOACTIVITY IN MOUNTAINOUS REGIONS. Dimchev, Todor. Izv. Fiz. Inst. Aneb, Bulg. Akad. Nauk.; 19: 199-214(1969). (In Bulgarian).

Relatively high concentrations of long-lived activities were determined for some regions of the mountains Vitosha, Rila and Pirin for the period 1961 to 1964. The local accumulation of radioactive fallout fission products (due to the nuclear tests in the atmosphere) was determined. Long-lived artificial radioactivity was also found on the surface of snow drifts on the northern mountain peak slopes left during the summer months. It was determined that radioactive fallout concentrating under the influence of meteorological, hydrological, and orographical factors may bring about mountain centers with a very high level of the local radioactive contamination. In these geographic latitudes this takes place under the conditions of global dispersion of long-lived fission products, originating in the stratospheric reservoir. The possibility for direct measurement of the created anomalies in the gamma background distribution is proved in the course of the investigations. Hot spots with values of the gamma background reaching 100 $\mu$R/hr at a height of 25 cm were determined experimentally in some mountainous regions for the period 1961 to 1963. The results of the gamma-spectrometric examinations of characteristic samples, taken from mountainous regions of Southwest Bulgaria were considered. Identification of the radionuclides was carried out and a qualitative estimate of their relation in the mixture of fission products made. The energy distributions of irradiation of some natural gamma emitters contained in the samples are given for comparison. A scintillation spectrometer with the NaI(Tl) crystal dimensions 127 × 50.8 mm and a 200 channel analyzer were used. The presence of $^{144}Ce + ^{144}Pr$, $^{137}Cs$, $^{95}Zr + ^{95}Nb$, $^{106}Ru + ^{106}Rh$ was determined from the gamma spectra. The conclusion that the concentration of the natural radioisotopes is negligible in comparison to the concentration of the long-lived fission products: $^{144}Ce$, $^{137}Cs$, $^{95}Zr + ^{95}Nb$ is drawn on the basis of the intensity of the full absorption peaks. This conclusion holds true only for small areas in some mountainous regions. (auth)

## Mineralogy and Exploration

*Refer also to abstract 16874.*

16712 THE ASSOCIATION OF URANIUM WITH NATURALLY OCCURRING ORGANIC MATERIALS IN THE COLORADO PLATEAU AND OTHER AREAS. Haji-Vassiliou, Andreas. New York; Columbia Univ. (1969). 265p.

Thesis.

Urano-organic associations may be divided into various types mainly on the basis of their geological mode of occurrence. In order to understand the nature of these associations more fully, the following problems have been considered: the origin or source of the associated organic matter; the form of occurrence of the associated uranium; and the probable mechanisms responsible for their formation. Most of the types of associations studied here represent occurrences in the Colorado Plateau area. Selected localities include the sandstone-type deposits at Temple Mountain, Utah and at Ambrosia Lake, New Mexico; the uraniferous carbonaceous shale near Gallup, New Mexico; and the urano-organic matter in sulfides and altered volcanic rocks at La Bajada, New Mexico. The non-Plateau occurrences are also included: The uraniferous lignite of South Dakota, and the thucholite of the Rand conglomerates of South Africa. The two basically different sources of organic matter in rocks and sediments are terrestrial plant derivatives (or coal) and petroleum derivatives. Geological evidence indicates that both petroleum and plant derivatives have contributed to the formation of the Temple Mountain ore. Similar evidence shows that plant derivatives constitute the most probable source for the organic fractions in the urano-organic deposits at Ambrosia Lake and Gallup, and, certainly, in the uraniferous lignite. The mode of occurrence of the ore at La Bajada suggests petroleum as the source. The source for the thucholite is not clearly differentiated in terms of geological evidence alone. Physical properties did not decisively relate the origin of the impregnated organic matter to either of the two basic sources, but furnished certain suggestions. These suggestions became definite indications upon consideration of refractive indices and chemical-structural data obtained mainly through organic elemental analysis, infrared spectroscopy, and vacuum differential thermal analysis. A final consideration of both geological and physio-chemical evidence indicates plant derivatives as a major source for the organic components in all but one of the deposits. Petroleum is indicated as the main source for the organic fractions in the La Bajada deposit, as well as a

major source (along with coal) for the Temple Mountain ore. Microscopic and x-ray data show the presence of primary uranium minerals (uraninite or coffinite) in the urano-organic ores at Temple Mountain and Ambrosia Lake, and in the thucholite. No uranium minerals were identified in the La Bajada ore or in the uraniferous organic shale. Only secondary uranium minerals have been found in the highly uraniferous lignite. The relationship of the uranium content to the ash content of mechanically fractionated portions of representative samples from each deposit indicates that most of the uranium in the urano-organic materials from Temple Mountain, Ambrosia Lake, and La Bajada is related to the mineral content of these materials; and most of the uranium content of the lignite and carbonaceous shale is closely associated with the organic components. Several investigators have demonstrated the capacity of organic matter to adsorb or reduce large amounts of uranium from uranium-bearing solutions. In terms of the evidence obtained on the nature of the urano-organic deposits, the accumulation and deposition of most of the uranium in the lignite, the carbonaceous shale, and the ore at Ambrosia Lake and La Bajada may be attributed to such a capacity for the organic components. The major mechanism of formation of the South African thucholite and the ore at Temple Mountain seems to be the pseudomorphic replacement of pre-existing uraninite by activated organic matter. (Diss. Abstr.)

**16713** PODZEMNOE VYSHCHELACHIVANIE URANOVYKH RUD. (Underground Leaching of Uranium Ores). Bakhurov, V. G.; Vecherkin, S. G.; Lutsenko, I. K. Moscow; Atomizdat (1969). 152p.

A general review is given of methods for the underground leaching of uranium from solid rock and sedimentary deposits. The physicochemical basis of the leaching process is described, and suggestions are made for more efficient prospecting and exploration methods. The underground leaching of copper, salt, potassium salts, sulfur, gold, and other minerals is also discussed. 113 references are included. (R.V.J.)

**16714** ORIGIN AND CONTROLS OF URANIUM MINERALIZATION IN SOUTH ALLIGATOR VALLEY. Taylor, J. (United Uranium, N. L., Melbourne). At. Energy Aust.; 12: No. 4, 18-24(Oct 1969).

An abstract of this paper previously appeared in NSA as 23: 40893.

**16715** MINING PRACTICE IN THE SOUTH ALLIGATOR VALLEY. Fisher, W. J. (United Uranium, N. L., Melbourne). At. Energy Aust.; 12: No. 4, 25-40(Oct 1969).

An abstract of this paper, previously appeared in NSA as 23: 40896.

**16716** URANIUM FOR THE EUROPEAN COMMUNITY. Spaak, F. pp 79-102 of Utilizzazione del Combustibile Nucleare. Roma; Comitato Nazionale Energia Nucleare (1969).

From 10th International Nuclear Energy Conference, Milan, Italy. See CONF-681219.

The situation of the natural uranium industry in the European Community, taking stock of the efforts and results of the prospecting activities in the different member countries and giving estimates on the reasonably assured and possible additional uranium reserves workable at a price of $8.00 to $10.00 lb/$U_3O_8$ is discussed. This includes the present production program based on the reserves, the size and scope of current prospecting activities estimated and compared with similar activities in third countries, and the role and activities of ways and means provided by the Euratom Treaty in order to develop a viable European natural uranium industry to ensure a regular and equitable supply of uranium to the Community users. (auth)

**16717** URANIUM EXPLORATION AND PRODUCTION ACTIVITIES IN THE UNITED STATES. Faulkner, R. L. (Atomic Energy Commission, Washington, D. C.). pp 103-18 of Utilizzazione del Combustibile Nucleare. Roma; Comitato Nazionale Energia Nucleare (1969).

From 10th International Nuclear Energy Conference, Milan, Italy. See CONF-681219.

Over 100 nuclear-fueled power plants have been sold in the United States, touching off greatly expanded uranium exploration activities. Most of the U.S. production is derived from uranium deposits occurring in horizontal sandstone beds. Although to date production has been from deposits at depths of less than 1,500 feet, workable deposits have now been found at depths of nearly 3,000 feet. Only a year ago the uranium industry planned about 50 million feet of drilling for the four-year period 1967 through 1970. A survey indicated that drilling will be stepped up to nearly 100 million feet for the four-year period 1968 through 1971, an average of 25 million feet per year. This compares with the highest level reached during the previous exploration program of about 9 million feet drilled in 1959. Major oil companies bring their financial resources to bear on the problem of finding uranium as well as their expertise in searching for mineral resources. Approximately half of the known ore reserves in the United States are workable by open-pit methods, but only one-third of the current production is from open pits. Although more than 350 mines in the United States feed the currently operating 16 ore processing plants, 90% of the production comes from about 60 large deposits. The present U.S. reserve situation will permit expansion of existing plants and the opening of new plants depending on the discovery of new ore reserves within reasonable haulage distance. The upward swing in the rate of exploration in the United States is beginning to be reflected in additions to known ore reserves despite increased production rates. (J.C.W.)

**16718** A CANADIAN VIEW OF THE URANIUM SUPPLY SITUATION WITH REFERENCE TO CANADIAN EXPLORATION ACTIVITIES. Lowell, A. F. pp 119-27 of Utilizzazione del Combustibile Nucleare. Roma; Comitato Nazionale Energia Nucleare (1969).

From 10th International Nuclear Energy Conference, Milan, Italy. See CONF-681219.

The world demand for uranium through 1971 is now concretely fixed, and it will continue to rise steeply thereafter. The problem of arranging supply to meet rising demand in the shorter term will be dealt with at great length. There is a lead-time problem in developing new production both from shutdown mines and mills and from those fairly few new discoveries of economic reserves so far reported which are capable of supporting new production. If, as seems to be generally accepted, a maximum annual production rate from the known low cost reserves will be required by about 1973, then mining companies owning such reserves should be planning now to develop them to production in order to be producing by 1973. There is a real risk of some physical shortage of $U_3O_8$ in 1973, which may necessitate some releases from government-held stockpiles. After about 1973, it is clear that all incremental demand for uranium will have to be met from new uranium ore reserves not yet discovered and reported. The exploration drive for new uranium ore reserves in Canada for this drive and the possible economic consequences are discussed. (J.C.W.)

**16719** PATHFINDERS IN GEOCHEMICAL PROSPECTING FOR URANIUM IN NEW ZEALAND. Cohen, Noel E.; Brooks, Robert R.; Reeves, Roger D. (Massey Univ., Palmerston North, N. Z.). Econ. Geol.; 64: 519-25(Aug 1969).

Elemental associations in uranium minerals of the Lower Buller Gorge region of New Zealand were studied throughout the weathering sequence, minerals-soils-stream sediments, in order to discover suitable pathfinders for uranium in this area. Beryllium, copper, and lead were found statistically to be good pathfinders for uranium in soils. In stream sediments, only copper gave an indication of uranium mineralization in the drainage area of the streams concerned. An additional pathfinder in stream sediments was the copper/lead ratio for which values of 0.80 and above apparently indicated the presence of uranium mineralization in the vicinity. Positive results were obtained for a stream not previously known to drain uranium anomalies. Additional work provided further evidence of mineralization near this stream. It was concluded that the work has shown the feasibility of using soils and stream sediments to prospect for uranium in an area in which access is extremely difficult. (auth)

## Oceanography

*Refer also to abstracts 16696 and 16802.*

**16720** RADIOCARBON FROM NUCLEAR TESTING AND AIR-SEA EXCHANGE OF $CO_2$. Fairhall, A. W.; Buddemeier, R. W.; Yang, I. C.; Young, A. W. (Univ. of Washington, Seattle). Contract AT(45-1)-2091. Antarctic J. U. S.; 4: 184-5(Sep-Oct 1969).

Transfer of $^{14}C$ (produced by nuclear weapons testing) from the troposphere to the sea is causing the level of $^{14}C$ in the troposphere to decline slowly, while the near-surface levels of the sea become enriched. The rate of air-sea exchange of $CO_2$ is expected to be proportional to the square of the wind speed over the sea surface. The large ocean areas and high wind speeds at southern latitudes mean that the bulk of the weapon test-released $^{14}C$ will probably be taken up by the oceans. A study is being made of this uptake by a total-$CO_2$ sampling program aboard USNS Eltanin. Samples of water are being collected from various depths to 4000 m at locations south of Australia. The limited data available at present show that $\Delta^{14}C$, the isotope-corrected deviation from the preatomic era concentration of the terrestrial biosphere, was as

low as –269. On this scale, the preatomic test levels of most of the surface ocean is generally taken to be –50. In comparison, the data obtained show that significant amounts of weapon released $^{14}C$ have been taken up by the ocean at high southern latitudes. This weapon-released $^{14}C$ should serve as a useful tracer for determining the rate of air-sea exchange of $CO_2$ and for tracing the advection and mixing of the various ocean-water masses. For example, the Upper Deep Water, with a $\Delta^{14}C$ value of –60, corresponds to a water mass originating in the North Atlantic before the atomic era. The higher concentration of $^{14}C$ in the water masses above and below shows that these have a fairly recent origin at the surface. (BBB)

## Seismology

*Refer also to abstracts 16727 and 16920.*

**16721** (NVO–1163–197) OBSERVED SEISMIC DATA, RULISON EVENT. (Environmental Research Corp., Alexandria, Va.). 14 Nov 1969. Contract AT(29-2)-1163. 79p. (PNE-R-16). Dep. CFSTI.

The results of the processing of the observed ground motions from the Rulison event are presented. The observed peak particle amplitudes as a function of distance are compared with predictions based upon a 40 kt yield. The observed 5% horizontal component Pseudo-Relative Velocity (PSRV) spectra (peak response) are compared with the 40 and 60 kt spectral predictions. Data recorded at 36 instrument stations by United States Coast and Geodetic Survey (USC&GS) were processed by Environmental Research Corporation's (ERC) Data Processing Laboratory. (auth)

**16722** ANALYSES OF GROUND MOTIONS AT UNION BAY, SEATTLE DURING EARTHQUAKES AND DISTANT NUCLEAR BLASTS. Seed, H. Bolton; Idriss, I. M. (Univ. of California, Berkeley. Woodward–Clyde and Associates, Oakland, Calif.). Bull. Seismol. Soc. Amer.; 60: 125-36(Feb 1970).

Recordings of accelerations at three different depths within the soil profile at Union Bay were obtained during a mild nearby earthquake and three distant nuclear blast events. These recordings were made by instruments which had been placed in peat 10 feet below the ground surface, in clay 61 feet below the ground surface and in glacial till 105 feet below the ground surface. Accelerations in the EW, NS and vertical directions were recorded simultaneously at these three depths. Using an equivalent linear variable damping lumped-mass solution, incorporating strain-dependent material properties for the peat and clay layers, the motions throughout the deposits were computed. The recorded accelerations in the glacial till were used as input base motion. Comparisons of the time histories of accelerations, maximum accelerations and spectral values of the motions recorded during the nearby earthquake with the corresponding computed motions indicated a high degree of agreement. The maximum accelerations recorded during the distant nuclear blast events also compared well with the computed accelerations. (auth)

**16723** AN ENGINEERING INTENSITY SCALE FOR EARTHQUAKES AND OTHER GROUND MOTION. Blume, John A. (John A. Blume and Associates Research Div., San Francisco). Bull. Seismol. Soc. Amer.; 60: 217-29(Feb 1970).

An engineering intensity scale is proposed for earthquakes and for ground motion resulting from nuclear or chemical explosions. It is based upon 5% damped response spectra developed from the ground motion and a standard 10 × 9 matrix with columns representing period bands and rows representing prescribed response velocity levels, $S_v$. Acceleration or relative displacement can also be readily assigned with the use of 4-way logarithmic paper. The EI scale can be reported by period column as 9-digit, 3-digit, or 1-digit numbers, or by all three in a standard format. The more digits reported, the greater the amount of information on the period bands. The advantages over existing scales are many including ratings that are directly informative and useful in damage estimations and which ratings are made objectively and have period identification lacking in other scales. Some example EI ratings are provided. (auth)

**16724** MOTION AND DAMPING OF BUILDINGS RELATIVE TO SEISMIC RESPONSE SPECTRA. Blume, John A. (John A. Blume and Associates Research Div., San Francisco). Bull. Seismol. Soc. Amer.; 60: 231-59(Feb 1970).

The response spectrum is very useful in dynamic analysis even though its use for multimass systems involves approximations as to modal combinations. It is especially useful in predicting effects of possible real earthquakes or of proposed nuclear detonations because it may be postulated or predicted much more readily than a complete time history of ground motion. The relationships of multimass system response — in terms of displacement, velocity, acceleration, force, shear, and moment — to elastic spectral response are given, together with examples taken from the AEC nuclear testing program in Nevada. The effects of relative building stiffnesses and stiffness taper on mode shape and thus on response are shown, as are the base shears relative to spectral response for several idealized fundamental mode shapes. A spectral Response Reconciliation procedure is presented and demonstrated by which procedure spectral response is reconciled with measured real building motion to obtain damping or other data under actual response to ground motion of any intensity. Damping values of high-rise buildings are determined by this procedure. Comparisons are made between 5% damped response spectral values at the fundamental mode period of buildings and measured building motion. (auth)

**16725** REFLECTIONS FROM EARTH'S CORE CAUSED BY ATOMIC EXPLOSIONS AND PROBLEMS OF THE EARTH'S INTERNAL STRUCTURE OF THE EARTH. Vinnik, L. N.; Dashkov, G. G. (O. Yu. Shmidt Inst. of Earth Physics, Academy of Sciences, USSR). Dokl., Earth Sci. Sect. (Engl. Transl.); 184: 10-13(Jan-Feb 1969).

Models of the density variation of the Earth's core are examined on the basis of seismic data from underground nuclear explosions. Reflections offer the possibility of extracting direct information about environmental parameters on both sides of the core-mantle boundary. One difficulty in the interpretation of observations is the inexplicably high value of the ratio of PcP to P (amplitudes of reflected and refracted longitudinal waves) and, consequently, of the reflectance from the core boundary. Analysis of the records of atomic explosions kept by seismic stations in the USSR indicates that this hitherto contentious and inexplicably high PcP/P value is a product of incorrect processing of observational results. The spread of individual PcP/P values is so great that the PcP wave is quite unrecognizable over almost half the area of seismograms, whereas it is compatible in amplitude with P on others. The raw data for the analysis was provided by about 60 independent records of explosions. The results are interpreted in terms of a model in which there is a rise in velocity but not in density at the core-mantle boundary. In this model there is a layer of reduced velocities at the bottom of the mantle. A conclusion drawn from a comparison of the variances $\sigma^2_{PcP}$ and $\sigma^2_{P_{cP}P}$ is that, $\sigma^2_{P_{cP}P}$ is ~ 3 times higher than $\sigma^2_P$. The increase in the path traversed by PcP compared with P cannot be a factor, for $\sigma^2_P$ does not grow with distance. Thus, the main heterogeneities responsible for the spread in amplitudes of P are so situated in the crust and upper mantle that the path traversed by this wave increases together with the angle $\Delta$, the length of the active sector being practically constant. Then, to explain the greater spread in PcP amplitudes, it must be supposed that there is another highly heterogeneous zone at the bottom of the mantle. Qualitatively, a similar effect could be caused by roughness of the core boundary. (BBB)

# ENGINEERING

## Nuclear Explosions

*Refer also to abstracts 16676–16678, 16680, 16698, 16700, 16703, 16711, 16721, 17329, and 17979.*

**16726** (JAB–99-76) STRUCTURAL EFFECTS OF THE RULISON EVENT. (Blume (John A.) and Associates Research Div., San Francisco, Calif.). Dec 1969. Contract AT(26-1)-99. 35p. (PNE-R-17). Dep. CFSTI.

Project Rulison is a natural gas production stimulation experiment that took place in Garfield County of western Colorado on September 10, 1969. The design yield was 40 kilotons, with a maximum credible yield of 60 kilotons and a depth of burial of 8425.5 feet. The preliminary results are reported for post-event structural response investigations and evaluations of ground motion effects on buildings, hydraulic structures, and earth structures. A summary of current damage complaint investigations is also included. Appendix A presents perceptibility observations. (auth)

**16727** (PNE–1012) PROJECT GASBUGGY: FINAL REPORT ON STRUCTURAL RESPONSE. (Blume (John A.) and Associates Research Div., San Francisco, Calif.). Nov 1969. Contract AT(26-1)-99. 64p. (PNE-G-59). Dep. CFSTI.

Results of structural response investigations associated with the Gasbuggy nuclear detonation executed for gas stimulation purposes in Rio Arriba County, New Mexico on December 10, 1967 are presented. Pre-shot investigations of selected close-in structures were conducted. Total damage cost was predicted to be approximately $35,000, based on data from these studies and ground motion predictions by the Environmental Research Corporation (ERC) for the maximum yield of 31 kilotons (kt). Actual damage to structures was essentially negligible. Of three damage complaints investigated, credible indications of seismically induced damage were found for only one. In this case, damage consisted of aggravation of cracking originally caused by a pre-existing settlement problem. (auth)

**16728** (UCRL–50635(Rev.1)) PROJECT GASBUGGY GAS QUALITY ANALYSIS AND EVALUATION PROGRAM TABULATION OF RADIOCHEMICAL AND CHEMICAL ANALYTICAL RESULTS. Smith, Charles F. Jr. (California Univ., Livermore. Lawrence Radiation Lab.). 17 Nov 1969. 20p. (CONF-700101–6; PNE-G-44(Rev.1)). Dep. CFSTI.

From Meeting on Engineering with Nuclear Explosives, Las Vegas, Nev.

Supersedes report UCRL–50635.

In the past, analytical results for samples of Project Gasbuggy chimney gas have been distributed to project participants and the interested public in various ways. This tabulation is an attempt to summarize all of the previous results with a consistent up-to-date listing of samples, radionuclide concentrations, and chemical analysis results and, at the same time, provide a vehicle for distributing these results. The listing includes the description and the disposition of all samples obtained for analysis at the Lawrence Radiation Laboratory following the Gasbuggy detonation. Radiochemical results expressed as concentrations in chimney or formation gas are given for $^{85}Kr$, HT, HTO, $CH_3T$, $C_2H_5T$, $C_3H_7T$, $^{14}CO_2$, $^{37}Ar$ and $^{39}Ar$. Upper limits for the concentrations of several nongaseous or semivolatile nuclides are presented. The tabulation also includes the percentages of $N_2$, $CO_2$, CO, $H_2$, $CH_4$, $C_2H_6$ and $C_3H_8$ in the sample gas as determined by mass spectrometry. (auth)

**16729** (UCRL–72159) CHEMICAL MINING OF PRIMARY COPPER ORES BY USE OF NUCLEAR TECHNOLOGY. Lewis, A. E. (California Univ., Livermore. Lawrence Radiation Lab.). 22 Dec 1969. 10p. (CONF-700101–4). Dep. CFSTI.

From Meeting on Engineering with Nuclear Explosives, Las Vegas, Nev.

Chemical mining of primary copper ores, with nuclear explosives to break the ore and in-situ hydrostatic pressure to accelerate dissolution of primary ore minerals, may be feasible. A contained nuclear explosion well below the water table would be used to provide a mass of broken ore in a flooded chimney. The hydrostatic pressure in the chimney should increase the solubility of oxygen in a water-sulfuric acid system enough to allow primary copper minerals such as chalcopyrite and bornite to be dissolved in an acceptably short time. Circulation and collection would be accomplished through drill holes. This method should be especially applicable to the deep portions of porphyry copper deposits that are not economical to mine by present techniques. (auth)

**16730** (USGS–474-41) A SUMMARY OF INFORMATION AND IDEAS REGARDING SINKS AND COLLAPSE, NEVADA TEST SITE. Houser, F. N. (Geological Survey, Denver, Colo.). Jan 1970. Contract AT(29-2)-474. 129p. (NTS–216). Dep. CFSTI.

The mechanism of collapse of nuclear explosion cavities is being investigated for its value in containment, with the hope of eventually determining those geological environments most susceptible to early collapse or most adaptable to the incitation of collapse. The Geological Survey has confined its investigations largely to subsurface collapse and surface subsidence that result from explosions in the alluvium of Yucca Flat. The topographic depressions formed as a result of surface subsidence, called sinks, are as much as 200 feet deep and 800 feet in radius; their forms are commonly variations of inverted cones or sectors of spheres. The central area of each sink is the top of a plug whose size, shape, and vertical drop all strongly influence the size and profile of the sink. A block that surrounds the central plug in the vast majority of sinks is an inward slide mass of slightly disoriented but relatively undisturbed alluvium. The main structural features within the slide mass are subsidiary spoon-shaped cracks and slide surfaces along which individual blocks have adjusted within the slide mass. The cracks or slide surfaces are assumed to flatten with depth within the slide and to join a major surface of failure at the base of the main slide mass. Where the spoon-shaped surfaces intersect the top surface of the slide, they dip steeply to vertically, and in plan, they make a pattern of curving intersecting cracks. Surrounding the slide mass are blocks that are extensively fractured and, in part, downdropped; these blocks form zones that are analogous to structural deformation at the heads of natural landslides. The depth of burial in alluvium of the explosion cavity, relative to its size, affects the relief and morphology of the sink; for a collapse not extending to the surface, the depth of burial affects the height of the chimney and, to an extent, the likelihood that later surface subsidence will occur. A working model of collapse includes: preservation of the explosion cavity until main collapse occurs; a two-phase collapse taking place in several seconds to tens of seconds, culminating in surface subsidence if the cavity is sufficiently close to the surface. The first phase of collapse, in alluvium at least, consumes 75 to 90 percent of the collapse period; collapse propagates upward at rates of 50 to 80 feet per second. The second phase shows faster rates of upward propagation and a lesser degree of particulation of the collapse material, and it ends with the drop of a central mass of alluvial material that initiates formation of the sink. (auth)

**16731** EARTHQUAKES AND NUCLEAR DETONATIONS. Anderson, Don L. (California Inst. of Tech., Pasadena); Archambeau, Charles B.; Brune, James N.; Richter, Charles F.; Smith, Stewart W.; (and others). Science; 167: 1011-14(13 Feb 1970).

A discussion is presented on a paper published recently by Emiliani et al., and previously abstracted in NSA as 23: 49979 on Underground Nuclear Explosions and the Control of Earthquakes. Results of the findings by Emiliani et al., are challenged in 3 discussions. The alleged correlation out to 860 km is questioned by Anderson et al. Allen and Bailey discuss many assumed factors by Emiliani. The creation of large areal surface loads by the backfilling of lakes behind man-made dams is a factor that should be included. Emiliani assumed a uniform distribution of earthquake occurrences during 8-hour intervals covering the 5 years studied. Allen and Bailey also believe it instructive to examine the given data in light of the accepted relationship between seismic energy release and recorded magnitude of body waves. Ryall and Boucher take issue with the main findings of Emiliani, that underground testing in Nevada has influenced earthquake activity over most of the conterminous western United States. In support of the challenges, Emiliani has published tabulated data for intervals of 8 hours, up to 104 hours, on earthquake occurrences from 104 hours before detonation and from 2160 hours after detonation for the total area. In an area from 430 to 860 km from the test site in 8-hour intervals from detonation, total earthquakes are given. (J.C.W.)

**16732** PLOWSHARE. Nucl. News; 13: 42-4(Jan 1970).

Underground nuclear explosions detonated to stimulate gas production include Project Rulison and Project Gasbuggy. Private companies are studying the possibility of gas stimulation in gas-bearing formations in Western and Appalachian areas of the U.S. Project Bronco will study the technical feasibility of fracturing oil shale with an underground nuclear explosion. Project Sloop is proposed to determine if a contained underground nuclear explosion can be used to fracture low-grade copper deposits. The Amchitka Island test was detonated 4,000 feet below the surface.

Data are being analyzed. Legislative actions taken recently are discussed concerning the United States and foreign programs, and the Atomic Energy Commission and other departments in the U. S. government. (J.C.W.)

## Facilities and Equipment

*Refer also to abstracts 17255, 17258, 17327, 17388, 17725, 17866, 18348, 18516, and 18737.*

**16733** (CEA-tr-A-1990) IRRADIATION CAPSULE TO TEST CORROSION IN WATER AT 320°C AND UNDER 110 ATMOSPHERES. Wilhelm, H. Translated from 16eme Seance du Groupe de Travail de l'Euratom "Irradiation Devices," Hambourg/Geesthacht, 9-10 May 1968. 14p. (In French). (CONF-680556-1). Dep. CFSTI (U. S. Sales Only).

An irradiation capsule for water corrosion tests was constructed. It is principally constituted of a steel autoclave surrounded by a safety vessel of $AlMg_3$. The autoclave is also provided with a supplementary safety device to protect against rupture on the upper clamp. The characteristics of the water corrosion capsule are described. The construction data of another capsule to remedy the faults found in the first capsule are outlined. (J.S.R.)

**16734** (CONF-690910–, pp 184-96) DEVELOPMENT AND FEASIBILITY TESTS OF ISOTHERMAL IRRADIATORS. Weaver, C. V.; Patrick, A. J.; Ranken, W. A. (Los Alamos Scientific Lab., N. Mex.).

Laboratory and reactor tests are described which are used to show that specimen temperatures in irradiation experiments can be established and regulated through the use of inert-gas-filled heat pipes. When properly constructed, such pipes will last almost indefinitely and require no servicing. With the wide choice of available working fluids, there is no real restriction on the operating temperature of such devices other than the temperature of the reactor coolant. (auth)

**16735** (CONF-690910–, pp 267-80) DEVELOPMENT OF FISSION GAS PRESSURE TRANSDUCERS AT ARGONNE NATIONAL LABORATORY. Folkrod, J. R. ([Argonne National Lab., Ill.]).

Development of fission gas pressure transducers of the null-balance and fluid-filled bellows-capillary types is described. The null-balance type, which most people are familiar with, works on the principle of a moving diaphragm which makes contact with a probe. Contact with the probe closes an electrical circuit and allows a gas solenoid valve to open. The gas, known as the reference gas, pressurizes the system and causes the diaphragm to break probe-diaphragm contact to close the valve. The pressure of the reference gas is then equivalent to the fission gas pressure. Further operation of the valve will not take place until the fission gas increases in pressure. The fluid-filled bellows-capillary transducer system may not be too familiar. It is, however, analogous to the large diaphragm-capillary fluid-filled systems built by Taylor and other well known like companies. The only difference is that the large diaphragm is replaced by a bellows. (auth)

**16736** (CONF-690910–, pp 281-95) CONTINUOUS MONITORING OF FISSION GAS RELEASE DURING IRRADIATION OF NUCLEAR FUEL SPECIMENS. Yarger, L. L.; Miller, N. E.; Ray, J. W. (Battelle Memorial Inst., Columbus, Ohio).

Development of a system to continuously monitor fission gas release from the fuel during irradiation is described. The system consists of a null-balance pressure transducer attached directly to a clad fuel specimen in the capsule. Fission gases escaping from the fuel collect within the cladding and exert pressure on a diaphragm in the transducer. A balancing pressure is introduced on the other side of the diaphragm and the null-balance position of the diaphragm is detected by an electrical contact which is part of a detection circuit. Instrumentation is provided to monitor the balance pressure, and the fission gas temperature and pressure is correlated with the known fission gas generation rate to calculate the fractional release from the fuel. In addition to monitoring fission gas release, the system also provides information on cladding integrity. Cladding failure is detected as a large reduction in pressure while operating at essentially constant temperature. This system has been used successfully in two irradiation experiments at fuel and cladding temperatures in excess of 1700°C. The data it provides on fission gas release have been used in conjunction with swelling data from neutron radiography to provide considerable insight into the phenomenology of the behavior of nuclear fuels during irradiation. (auth)

**16737** (CONF-690910–, pp 413-19) PYCNOMETER, PROFILOMETER, AND LASER PUNCTURING FOR SPACE REACTOR FUEL CAPSULE EXAMINATION. Dismuke, S. E. (Oak Ridge National Lab., Tenn.).

Development of apparatus to obtain data on bulk density of swollen and cracked space reactor fuel pellets and data from continuous diameter and profile measurements on 4½ in. test capsules is described. Equipment to puncture these capsules for gas collection without cracking the capsule wall is also described. A pycnometer was developed to measure the bulk volume from which the bulk density of porous fuel pellets is determined in a hot cell. A profilometer is provided for in-cell measurement of the profile and diameter of small cylindrical specimens. A laser beam is used for cladding puncture. (J.R.D.)

**16738** (CONF-690910–, pp 420-34) TECHNIQUES AND APPARATUS FOR INSPECTION, HANDLING, AND ANNEALING HIGHLY RADIOACTIVE FUEL MICROSPHERES. Morgan, M. T.; Towns, R. L. (Oak Ridge National Lab., Tenn.).

Techniques and equipment have been developed for remote handling, inspecting, and annealing of coated nuclear fuel microspheres. The equipment is adapted for use in shielded glove boxes and includes a revolving microprobe stage with vibrator to turn particles over remotely, a suction pickup, wrist-action manipulators, a Geiger-Mueller tube probe, an induction-type annealing furnace, and a separate gas collection and analysis system. (auth)

**16739** (CONF-690910–, pp 690-7) DESIGN OF A LEAD-TYPE CAPSULE SYSTEM TO INVESTIGATE THE RADIOLYSIS OF WATER. Sheibley, Dean W. (National Aeronautics and Space Administration, Cleveland, Ohio. Lewis Research Center).

The capabilities and design requirements of lead-type capsule systems are discussed. The systems allow in-pile measurements of pressure, temperature, and neutron fluxes during reactor operation. A capsule system has been shown to withstand and contain a 15,000 psi reflected shock wave due to detonation of confined gases. (auth)

**16740** (CONF-690910–, pp 742-58) CAPSULE DESIGN FOR DYNAMIC IN-PILE FRICTION EXPERIMENTS. Jacobson, T. P.; Kerkhoff, R. E.; Christenson, H. H. (National Aeronautics and Space Administration, Cleveland, Ohio. Lewis Research Center).

A capsule design is described for a lubricant irradiation experiment at the NASA Plum Brook Reactor Facility. The capsule contains a friction and wear test apparatus for conducting dynamic experiments in reactor radiation up to $5 \times 10^{12}$ n/m²-sec (E > 1 Mev). Techniques that increase the reliability of these experiments and improve the hot lab capability of making repairs are illustrated. These techniques include special methods of measuring and controlling test specimen temperature and a modular design using linear variable differential transformers to measure friction coefficients during radiation exposure. Initial in-pile operations are also discussed. (auth)

**16741** (CONF-690910–, pp 759-74) REMOTE ENCAPSULATION AND TREAT CAPSULE HANDLING TECHNIQUES. Culley, G. E.; McMahan, M. E. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.).

Equipment and procedures have been developed for the remote encapsulation of pre-irradiated fuel pins to be transient irradiated in the TREAT facility in support of the FFTF driver fuel development program. The fuel pins to be encapsulated are steady-state irradiated in either the GETR or EBR-II. The GETR type fuel pins are irradiated in an instrumented NaK-bonded capsule which is remotely encapsulated by inserting the GETR capsule into a pressure vessel known as a TREAT capsule. The EBR-II type fuel pins are removed from the sodium-bonded capsules used during steady-state irradiation and re-encapsulated into an instrumented capsule very similar to the GETR capsule which is, in turn, inserted into the TREAT capsule. The remote equipment utilized during re-encapsulation includes a fuel pin profilometer, a gamma scanner, a programmed welding station, a leak detection system, and a NaK filling system. The equipment used in encapsulating into the TREAT capsule includes a positioning table, a torque wrench, a leak detection system, and an instrumentation and heater checkout system. Shipping cask handling facilities which enable the use of the T-2 cask horizontally include a motorized dolly and turntable. (auth)

**16742** (COO–1393-1) EVALUATION OF PROTECTION FROM EXPLOSION OVERPRESSURE IN AEC GLOVEBOXES. Yao, C.; deRis, J.; Bajpai, S. N.; Buckley, J. L. (Factory Mutual Research Corp., Norwood, Mass.). Dec 1969. Contract AT(11-1)-1393. 127p. (FMRC–16215.1). Dep. CFSTI.

A theoretical and experimental research program was undertaken to collect and generate knowledge pertaining to the problem of explosion venting and to apply this information specifically to AEC glovebox safety and protection. A general mathematical model describing the explosion characteristics inside a vented en-

closure was derived which can be solved numerically to predict the pressure-time history for a wide variety of venting arrangements such as free-vent, bursting diaphragm relief venting, and filter venting. Good agreement was obtained between theoretical and experimental results for cases of localized explosion in a closed vessel and completely filled explosion in an enclosure with free-vent. For bursting diaphragm explosion relief venting, the calculated and measured pressure-time record showed distinct double pressure peaks, whose characteristics depended on the pressure at which relief occurred. The information obtained from this investigation was analyzed and reduced to general guidelines for explosion protection in gloveboxes. A general procedure for designing a bursting diaphragm type of explosion relief, and methods for confining and exhausting the explosion discharge from the glovebox are presented. (L.C.L.)

**16743** (NYO–3839-8) A TWO PHASE FLOW ROTOR BEARING SYSTEM: PREPARATIONS FOR AN EXTENDED (500 HOUR) TEST. Progress Report, October 1–December 31, 1969. Finkin, E. F.; Malanoski, S. B. (Mechanical Technology Inc., Latham, N. Y.). Jan 1970. Contract AT(30-1)-3839. 16p. (MTI–70-TR-5). Dep. CFSTI.

Preparations for a 500-hr-long test on a two-phase flow rotor bearing system using steam as the lubricating process fluid are described. (L.C.L.)

**16744** (TID–4100(Suppl.56)) ENGINEERING MATERIALS LIST. Supplement 56. Smith, Richard J.; Sachs, Francis L.; Clark, Willie E. (eds.) (Division of Technical Information Extension (AEC), Oak Ridge, Tenn.). Feb 1970. 42p. Dep. CFSTI.

Twenty-five packages of engineering drawings are presented on the prototype UV analyzer, digital wide range neutron detection and measurement channel, revisions to standard manual, aerosol monitor, $UF_6$ sampling buggy, pulse count converter system, wiring and ground loop of portable checker, variable coaxial cable compensator, time-of-flight interface, plastic sealing equipment, electrodeposition power supply, bio-particle carbon analyzer, heat-sensing thermal battery, large shielded-source irradiator, viewing window, 12-in. calciner module, sodium vapor detector, continuous gamma monitor, frequency swept NMR spectrometer, LMF cask, N-12 laser head, bismuth shipping cask, wide-range radiolysis source for mass spectrometer, 35-mm recording camera, and graphite irradiation experiments. A subject index is included. (L.C.L.)

**16745** (UCRL–19432) STRAIN GAGES: POSTAGE STAMP STRESS ANALYZERS. Krevitt, Roland (California Univ., Berkeley. Lawrence Radiation Lab.). Jan 1970. Contract W-7405-eng-48. 28p. (CONF-700108–1). Dep. CFSTI.

From 2nd Western Area Research and Development Safety Seminar, Berkeley, Calif.

The theory, development, characteristics, and uses of bonded resistance strain gages are discussed. Several examples of applications such as on space vehicles, racing cars, and pressure vessels are described and illustrated. (L.C.L.)

**16746** (UCRL–50756) DESIGN CONSIDERATIONS FOR RIB-STIFFENED FLANGES. Blake, Alexander (California Univ., Livermore. Lawrence Radiation Lab.). 23 Sep 1969. 53p. Dep. CFSTI.

A review of existing design formulas and theoretical considerations applicable to standard flanges is presented and an approach to the analysis of stresses in rib-reinforced flanges subjected to axial loading is emphasized. The recommended formulas and procedures are aimed at reducing the calculation time and reducing the overall weight of downhole-hardware for underground nuclear testing. The parametric equations and working formulas presented in the report form the basis of the line-of-sight computer program presently under development at Lawrence Radiation Laboratory. (auth)

**16747** APPARATUS FOR TAKING SAMPLES OF POWDER. Manevy, Georges (to Commissariat a l'Energie Atomique). British Patent 1,181,625. 18 Feb 1970. Priority date 4 Aug 1967, France.

An apparatus designed to obtain a representative sample from a mass of powder contained in a vessel is described. The design is such that the sample specimen is a small fraction of the quantity of powder present in the vessel. The apparatus can be remotely controlled and can be used to control contamination by dust during sampling. (J.R.D.)

**16748** A METHOD OF PRE-STRESSING PRESSURE TANKS, AND TANKS MADE BY THE METHOD. Birkenmaier, Max; Brandestini, Antonio; Ross, Mirko Robin. British Patent 1,181,544. 18 Feb 1970. Priority date 14 Sep 1966, Switzerland.

A method of prestressing pressure tanks by encircling the OD with wire cables is described. The method can be used advantageously with concrete tanks. (J.R.D.)

**16749** APPARATUS FOR PRODUCING A COLLIMATED BEAM OF RADIOACTIVE RAYS. Radcliffe, Thomas J.; McElhaney, Daniel M, Jr.; Havel, Daniel F. (to Republic Steel Corp.). U. S. Patent 3,496,361. 17 Feb 1970. Filed 7 Jul 1966.

A block of radiation absorbing material having a first bore extending inwardly from a point on the external surface of the block and meeting a second bore extending inwardly from another point on the surface is described. The two bores may be diametrically opposed so as to make up a single bore, or they may meet at an angle. A bolt is inserted in the first bore. The bolt has a recess near its inner end holding a source of radioactive rays. When the bolt is in place, the source is aligned with the second bore. A thin plug may be placed in the outer opening of the second bore. The plug is permeable to radioactive rays and serves to prevent entrance of dirt into the bore. This plug is replaceable by a thicker plug of absorbing material which serves to block radiation completely. The block is mounted between a pair of parallel plates connected by through bolts. The block may be cylindrical or it may have spherical shape such that it may be rotated universally between the plates. A shutter pivotally mounted on one of the through bolts may be provided so as to block the radioactive rays in one position, and to allow free exit of rays in another position. (Offic. Gaz.)

**16750** MODULAR THREE-SECTION 150-kG MAGNET FOR LABORATORY USE. Schindler, H. C. (RCA Electronic Components, Harrison, N. J.). Cryogenics; 10: 58-61(Feb 1970).

A three-section modular superconductive magnet which was layer wound from copper clad $Nb_3Sn$ ribbon is described. This produces a field of 150 kG with all three sections operating in series and a field of 105 kG with the outer section removed. The magnet has a bore of 1.5 in. but this can be increased to 4.75 in. by removing the inner bore; the field then produced is 110 kG. (auth) (UK)

**16751** PRESSURE RESISTING SEAL. Hopkins, Leslie Arthur; Harris, Benjamin Lewis (to National Research Development Corp.). British Patent 1,180,234. 4 Feb 1970. Filed 11 Mar 1967.

It is stated that with none of the conventional type seals can access be obtained from the low pressure side to the high pressure side, or vice versa, without substantially increasing leakage across the seal. The object of the design of the seal described is to provide an improvement in this respect. The seal comprises means defining an aperture having a number of closure members formed of flexible sheet material, capable of being inflated by pressurised fluid confined on one side of the seal. Each closure member comprises a closure portion and a pair of cheeks defining a concavity the hollow of which is presented towards the fluid side of the seal, and the arrangement of the closure members is such that when inflated their closure portions extend inwardly from the periphery of the aperture, the cheek portions serving as ties to restrain the closure portions against the fluid pressure; adjacent cheek portions of neighbouring closure members are urged together to provide a seal between peripherally adjacent closure members. The closure members may be formed with two closure portions having cheek portions in common, with non-return valves in each closure portion to permit inflation of the closure members by pressurized fluid on either side of the seal. A number of different arrangements of component parts is described. (UK)

**16752** SURVEY OF ADVANCED STRUCTURAL DESIGN ANALYSIS TECHNIQUES. Zudans, Zenons (Franklin Inst. Research Labs., Philadelphia). Nucl. Eng. Design; 10: 400–40 (Aug 1969).

An extensive continua survey, critical review, and basic development of linear elastic analysis methods for one-, two-, and three-dimensional continua are presented. For each of the continua the basic variation principles, significant for the development and understanding of the fundamentals of the structural analysis are given, and their use in deriving the basic equations is demonstrated. In some instances the results presented are original and in some cases they are given in a novel form. The detail intermediate steps are omitted to keep the basic picture as sharp as possible. An attempt is made to select from the tremendous number of various proposed finite elements, the ones that are adequate for engineering applications in machine design and are not too complicated to make their use cumbersome or uneconomical. No discussion of computer programs is presented, however, it is understood that many present structural analysis problems are solved by the use of a computer. References cited in the discussion of various theories contain dis-

cussion and outline of computer programs utilizing the respective theories. (auth)

**16753** ATR PRIMARY COOLANT SYSTEM 20 INCH CHECK VALVE (31 Jan 1969) (Engineering Materials). (Idaho Nuclear Corp., Idaho Falls). (CAPE-1957).

4 drawings.

A check valve, located in the discharge lines of primary pumps in the primary coolant system of the ATR, limits backflow through the pumps in the event of pump failure or loss of commercial power. During a pump failure, the check valve of the stopped pump must close so that the piping system is not subjected to excessive pressure surges or water hammer. Valve design pressure is 485 psig, maximum pressure drop across a fully opened valve is 7.5 psi at a flow of 18,000 gpm, differential pressure across the seat is 1.21 psi and leakage is less than 2 gpm with a differential pressure of 225 psi across the valve. Design temperature is 70°F initial, 130°F normal, and 240°F maximum. The valve is designed to withstand total radiation exposure of $5 \times 10^7$ rads of a dose rate of 500 rads/hr. (For details see TID-4100 Suppl. 57) (See also 22: 32974). (F.S.)

**16754** CALCULATION OF THE SPATIAL STRAIN STATES IN PRESSURE VESSELS WITH HOLES WITH THE HELP OF DYNAMIC RELAXATION. Schnellenbach, G. (Ruhr-Univ., Bochum, Ger.). Nucl. Eng. Design; 10: 476-502(Aug 1969).

The general axisymmetric stress and strain fields of prestressed concrete reactor pressure vessels usually are perturbed by a series of large openings in the vessel walls. While up to now the usual practice was to supplement the axisymmetric structural analysis of imaginary truly axisymmetric vessel structure by supplementing considerations on the areas surrounding the holes, now there is a trend for performing an integral three-dimensional vessel analysis. The mathematical difficulties do not allow analytical solutions, and numerical solutions of such problems have been performed up to now solely by use of the finite element method. It is shown that it is also possible to determine the three-dimensional stress and strain fields of prestressed concrete reactor pressure vessels by using the so-called dynamic relaxation method. The mathematical basis for such calculations is outlined, and the characteristics peculiar to this numerical procedure are discussed. Besides of some two-dimensional examples demonstrating the degree of exactness achievable for fulfilling the boundary conditions, the results of a three-dimensional analysis of a hollow cylinder with a quadratic opening are given. These examples are confined to the elastic region. Expansions of the mathematical basis for considering plastic and viscoelastic deformations are possible. (auth)

**16755** 138,600 kW STEAM TURBINE FOR THE ATOMIC POWER STATION IN KARACHI. Yamaji, Yasuhiro (Hitachi Ltd., Tokyo). Sangyo Kikai; No. 227, 6-10(Aug 1969). (In Japanese).

The 138,600 kW steam turbine for the atomic power station in Karachi, Pakistan is now being installed on the site. The power station employs a heavy-water, natural-uranium reactor. The specifications of the steam turbine are as follows: type, non-reheating four-current exhaust; rated power, 138,600 kW; rotation, 3000 rpm; inlet steam pressure, 544 psig; inlet steam temperature, 479.8°F; inlet steam moisture, 0.26%, exhaust pressure, 2.0 in. Hg abs. The type of steam turbine mentioned was determined by considering the steam-moisture separation efficiency, the relation between blade peripheral speed and moisture, as well as the economy. Specifications for the 138,600 kW steam turbine, piping, steam-moisture separators, are given. Methods for protection against erosion are also presented. (NSA of Japan)

**16756** IRRADIATION PROCESS AND APPARATUS. Jadot, A.; Saint Lebe, L. (to Commissariat a l'Energie Atomique). Canadian Patent 820,575. 23 Dec 1969. Priority date 19 Aug 1966, France.

To irradiate a product in divided form, it is placed in a packing, forming a thin flexible or jointed band which is moved linearly in a given circuit around a fixed radioactive source. Also, a relative oscillatory movement is produced between the band and the source perpendicular to the linear movement of the band. Ancillary equipment consists of a column for supporting a plate having rollers whose axes are perpendicular to the plane of the plate. There is also a hollow central roller for receiving a radioactive source and other rollers moving about their respective axes distributed round the central roller. A mechanism rotates at least one of the rollers and a flexible band contains the product to be irradiated and disposed in a circuit round the rollers, which drive it past the radioactive source. (F.S.A.)

**16757** THE UP-TO-DATE PROBLEMS OF STEAM TURBINES. Osvald, Kalman. Energ. Atomtech.; 21: 513-22(1968). (In Hungarian).

During the past decade there has been a marked increase in both the economy and unit capacity of the steam turbine. The increased use of steam turbines in nuclear power plants is predicted which will stimulate more research on ways to improve the design and performance of steam turbines. (auth)

**16758** BEHAVIOR OF METHYL IODIDE VAPORS IN SYSTEMS CONTAINING AIRBORNE RADIOIODINE. Cejnar, Frantisek (Inst. of Nuclear Research, Rez, Czech.). Jad. Energ.; 16: 42-7 (1970). (In Czech).

A review of the scientific literature on research and other data concerned with the formation, behavior and removal of gaseous methyl iodide in power reactor containment after a nuclear reactor accident was carried out. The amount of methyl iodide formed under particular conditions is the result of several competing mechanisms of formation and decomposition. Impregnated charcoal seems to be the most generally favored adsorbent for removing methyl iodide with the exception of too high humidity conditions. Additional work to define the mechanism governing the adsorption of methyl iodide particularly in multicomponent systems and to investigate the more selective adsorbents is needed. (auth)

**16759** CONTROL OF THE EFFICIENCY OF ABSOLUTE FILTERS INSTALLED IN VARIOUS NUCLEAR POWER PLANTS. Muzzi, F. (Univ., Pisa, Italy); Perinetti, M.; Zaffiro, C. Com. Naz. Energ. Nucl., Notiz.; 15: No. 10, 35-43(Oct 1969). (In Italian).

Methods of testing the filters for power reactors are discussed. A test rig used for the experimental evaluation of filters at the University of Pisa is described; a simplified schematic is shown. Dioctyl phthalate testing of filters is discussed. Efficiency values for filter systems are tabulated. (M.L.S.)

**16760** APPARATUS FOR IRRADIATING OBJECTS WITH SELECTED UNIFORM DOSES OF RADIATION. Kirkpatrick, William W.; Masefield, John (to Atomic Energy of Canada Ltd.). U. S. Patent 3,496,362. 17 Feb 1970. Filed 21 Oct 1965.

Apparatus for selecting and applying varying dose rates of radiation to an object is described. The apparatus includes means for shielding radioactive sources while a sample is being moved into and out of a radiation zone within the apparatus, and means are provided for selecting and moving varying numbers of the radioactive sources into radiating positions around the sample. Fluid pressure is used for moving the radioactive sources into radiating positions, and a plurality of the radioactive sources may be moved at one time by a single source of fluid pressure. (Offic. Gaz.)

**16761** DETERMINATION OF FILTER MATERIAL EFFICIENCY FOR RADON DAUGHTERS. Herrmann, D. B. (Staatliche Zentrale fuer Strahlenschutz, Berlin). Kernenergie; 12: 394-6(Dec 1969). (In German).

A method for determining the efficiency of filter materials for shortlived radon daughters is proposed. It is based on the comparison between the measured variation of the ionization current with time in an ionization chamber connected in series with the filter and the variation of current determined mathematically for various penetrations. (auth)

**16762** SELF-SHIELDED FESTOON FOR ELECTRON IRRADIATION APPARATUS EMPLOYING OVERLAPPING ROLLERS HAVING RADIATION BLOCKING MEANS. Kingsley, Gordon F.; Cram, Robert D. (to High Voltage Engineering Corp.). U. S. Patent 3,499,141. 3 Mar 1970. Filed 13 Nov 1967.

A self shielded flexible material irradiation apparatus is described that uses a flexible material equipment positioned outside of the irradiation chamber so that adjustments may be made thereto for varying parameters, such as the material speed or tension without exposing the operator to potentially hazardous radiation. (Offic. Gaz.)

**16763** SUPERCONDUCTING COILS. Couture, Claude. Atomes (Paris); 24: 528-31(Sep 1969). (In French).

Problems of construction of electromagnets for production of intense magnetic fields are reviewed; the problems of cooling a Cu magnet, even at low temperatures, are great enough to render this approach of little use. Instead, type-II superconducting magnets, especially using the alloys of Nb, are more applicable, though some problems exist, such as that of attaining a sufficiently low temperature for operation. Flux leaks, particularly in abrupt changes, are the potential source of considerable difficulty, and are especially important in long section of Zr–Ng alloy; inhomogeneities cause failure to function below the critical temperature for

shorter sections. Routes for circumventing this problem are described, particularly Laverick's idea of enveloping the superconductor with Cu. The construction of several American superconductor coils and the largest unit in Europe (Saclay, 40 kG in a diameter of 1 m) is described. Future uses of superconducting coils are outlined. (BBB)

**16764** METHOD OF TEMPERATURE CONTROL IN CAPSULE IRRADIATION VACUUM CONTROL METHOD. 2. Hayashi, Takao; Kudoh, Mitsuo (Japan Atomic Energy Research Inst., Oharai). J. Nucl. Sci. Technol. (Tokyo); 7: 72-81(Feb 1970).

A method of temperature control in capsule irradiation, vacuum control method, was presented previously in which both theoretical analysis and experimental results were discussed. The characteristics of the transient performance of this method are discussed. The theoretical analysis and experimental results were found to be in very good agreement, based on the mechanism of the automatic temperature control of this system and the key factors composing this system. (auth)

## Heat Transfer and Fluid Flow

*Refer also to abstracts 16790, 17378, 17379, 18508, 18616, 18623, 18637, 18638, 18652, 18770, and 18779.*

**16765** (ANL-7608) A STUDY OF THE INCIPIENT BOILING OF SODIUM. Holtz, Robert E.; Singer, Ralph M. (Argonne National Lab., Ill.). Oct 1969. 43p. Dep. CFSTI.

In experimental studies that measure the amount of liquid superheat required to nucleate the liquid alkali metals, conflicting and generally insufficiently explained data have been presented. The incipient-boiling superheat has been shown or postulated to be affected by the pressure-temperature history, liquid pressure, heat flux, liquid purity, dissolved-gas content, liquid velocity, surface conditions, nuclear radiation, heating method, length of time of operation, and perhaps others. Several of these effects are shown experimentally and theoretically to be interrelated and the relative importance of each is discussed. A theoretical analysis has revealed that the heat-flux and heating-method effects upon the wall superheat are explainable by inert-gas transport between the liquid metal and the surface cavities. It has also been demonstrated that the "bulk" liquid superheat is affected by the heat flux and liquid velocity as well as by the method used to approach incipient boiling. Experiments have shown that the preboiling history of an experimental apparatus determines the size of the available nucleation sites and "overrides" initial surface-roughness variations (for surfaces with "mirror" to "sandblasted" finishes) and surface corrosion. This history effect (as well as inert-gas transport) also explains the measured variation of wall superheat with increasing time of operation. The essential parameters that are needed to characterize liquid-metal, incipient-boiling experiments are listed. (auth)

**16766** (EURAEC-1915) BIBLIOGRAPHICAL REVIEW OF DNB DATA IN NON-UNIFORMLY HEATED CHANNELS AND COMPARISON WITH THEORETICAL PREDICTIONS BY WAPD-188, W-2 AND W-3 CORRELATIONS. Guyette, M.; Hoppe, N. (Societe Belge pour l'Industrie Nucleaire, Brussels). 29 Sep 1967. Contract 001-64-1-TRUB. 48p. (EUR-3397; CONF-670654-5). Dep. CFSTI.

Work performed under United States-Euratom Joint Research and Development Program.

From Symposium on Two-Phase Flow, Bournemouth, England.

A bibliographic review of departure from nucleate boiling (DNB) data in nonuniformly heated channels was carried out. The analysis of these data shows that the influence of the nonuniformities on the DNB decreases when the inlet quality increases, all the other parameters (geometry, pressure, mass velocity) being kept unchanged. Various methods of predicting DNB in nonuniformly heated channels were examined. A comparison between experimental values and theoretical predictions showed that the use of the F factor developed by Westinghouse, always improves the validity of the predictions for all the considered correlations. In the case of marked nonuniformities like hot patches and low qualities the discrepancies between experimental values and theoretical predictions were generally too large to allow the use of the selected method of calculation for detailed design and performance studies. (45 references) (auth)

**16767** (GEAP-13048) DEFICIENT COOLING. Quarterly Progress Report, No. 1, July 3-September 30, 1969. (General Electric Co., San Jose, Calif. Atomic Power Equipment Dept.). Oct 1969. Contract AT(04-3)-189. 14p. Dep. CFSTI.

Progress in the Deficient Cooling Program, is discussed. Sufficient planning and design have been done so that exploratory tests can commence. A 2-inch transient flow control valve was installed in the high-pressure heat transfer facility in preparation for transient flow tests. The turbine flowmeter of the loop was moved to a position downstream of the pumps for more effective metering and checking (with an orifice meter) of transient flow. A one-rod, 9-foot test section was redesigned for exploratory operations with Calrod heaters, and procurement of new materials was initiated. Analysis and procedures have been completed for conversion of recorded orifice pressure drop output data (including instrument lags) to the instantaneous flow at the orifice. Analysis of the system pressure transducer revealed that there was negligible time delay in the transducer. Recorded system pressures, from transient depressurization tests, were in agreement within 1 psi of calculated instantaneous values. (auth)

**16768** (JUL-585-RB) EXPERIMENTAL DETERMINATION OF CONVECTIVE HEAT TRANSFER IN CYLINDRICAL ABSORBER RODS FOR THE 300 MWe THTR PROTOTYPE. Presser, Karlheinz (Kernforschungsanlage, Juelich (West Germany). Institut fuer Reaktorbauelemente). Apr 1969. 17p. (In German). Dep. CFSTI (U. S. Sales Only).

The Sherwood numbers with the system naphthalene/air was measured on screw-shaped and cylindrical absorber rod models arranged in an irregular ball filling in the scale 1:10. With help of the analogy between material and heat transfer, the Nusselt numbers were calculated. The average convective Nusselt numbers for screw-shaped and cylindrical absorber rods are equal. They are about 15% lower than the Nusselt numbers found by Denton for spheres in an irregular ball filling. The average convective Nusselt numbers for the core wall is about 20% lower than the value found by Denton. (tr-auth)

**16769** (KAPL-P-3838) VARIATIONAL PRINCIPLE FOR THE LINEAR FISSION PRODUCT DEPOSITION PROCESS. Venerus, Ernest R. (Knolls Atomic Power Lab., Schenectady, N. Y.). [1966]. 5p. (CONF-691102-20). Dep. CFSTI.

From 17th Conference on Remote Systems Technology, San Francisco, Calif.

The problem of fission product transport and deposition in cylindrical conduits was examined. Two models which describe the various physical processes are proposed. A variational principle which governs both models and which permits the use of a general velocity profile is presented. The fission products were assumed to enter the coolant stream at a given axial location and to be transported downstream by convection. The first model, termed "The Resistance Model," is based on the assumption of a fictitious resistance to mass transfer at the interface between the stream and conduit surface. The second model, "The Transport Model," is based on actual physical transport processes between the stream and the tube surface. A rigorous mathematical solution was obtained for the Resistance Model, but a solution to the Transport Model was obtained only for the steady-state condition. A slug velocity profile was assumed in all cases. (L.C.L.)

**16770** (KFK-988) MISTRAL; THERMODYNAMIC UNDULATORY CURRENT ALGORITHM FOR ROD BUNDLE (16740). Baumann, W. (Kernforschungszentrum, Karlsruhe (West German). Institut fuer Reaktorbauelemente). June 1969. 36p. (In German). Dep. CFSTI (U. S. Sales Only).

A description is given of a digital computer program for the calculation of the local temperature and mass current in the cooling channels of a fuel element consisting of 61 rods. The computer method considers that the temperature difference between the central and near the wall cooling channels was affected by expansion, heat conductivity, and cross mixing of the coolant. For configuration of the method, studies were used which serve for the determination of the coolant cross mixing in air-cooled rod bundles. It was shown that a good agreement exists between the digitally calculated and the measured temperature profiles. The calculation method was also used for bundles of various clearance holders with sodium, steam, and helium as coolant. The method offers the possibility of estimating the case of thermal oblique load which is experimentally difficult to determine. (tr-auth)

**16771** (NP-18152) SOME HYDRODYNAMIC ASPECTS OF A BOILING WATER CHANNEL. Dijkman, F. J. M. (Technische Hogeschool, Eindhoven (Netherlands)). Dec 1969. 173p. Dep. CFSTI (U. S. Sales Only).

Thesis.

The influence of subcooling, of a sine-shaped heatflux, and of a combination of both on the steady-state and dynamic characteristics of a natural circulation, pressurized, boiling water system were studied. In natural circulation boiling systems hydrodynamic instabilities may occur at constant power. They appear to arise from a dependence of the vapor volume production rate upon the flowrate as a result of energy conservation and simultaneously the flowrate depends upon the resident vapor volume in the system as a result

of momentum conservation and continuity. The steam pressures were taken 15.5 and 30 atm, corresponding to saturation temperatures of 200° and 234°C respectively. Although the experimental results disclosed that the transition from stable to unstable behavior is not accompanied by a discontinuous change of all physical variables, preference has been given to a classification of the experiments in steady-state and dynamic measurements. It was preferred to incorporate the transfer function measurements in the dynamic part. Experiences with void measurements using the impedance technique are described. Measurements under steady-state conditions of the inlet velocity, the axial void distribution, and pressure drops at different conditions of channel power, subcooling at the inlet, flux-shape and pressure are discussed. Local values of the slipfactor and of two-phase friction were calculated. Steady-state noise and of oscillations under unstable conditions were analyzed in terms of amplitudes and phase differences of $\Delta p_{inlet}$ and the axially distributed voids. A limited number of transfer function measurements between the channel power as the perturbed quantity, and the dependent variables $\Delta p_{inlet}$ and the various axial voids, supplemented the experiments. The void propagation velocity as a function of frequency was compared with the expression of Zuber, based on the theory of kinematic waves. A theoretical study was made based on a solution of the familiar laws of conservation, with the addition of suitable expressions for the slipfactor, two-phase friction multiplier and the heat-distribution parameter in the region of subcooled boiling. No special attention was paid to the boiling boundary, the external system and estimated second order effects. The results of the computations were surprising owing to the close agreement with the experimental results with respect to the threshold-powers, the frequency, the destabilizing effect of moderate subcooling, and the influence of a non-uniform heatflux. It is concluded that the value of two-phase two-component measurements with the aim of transposition to boiling-water conditions is doubted. The influence of a non-uniform heatflux on the system stability is reviewed and its consequence is stated for dynamic boiling water experiments and for the anticipated stability of steamboilers in general and of boiling water reactors in particular. (auth)

**16772** (TID-25328) CONSIDERATIONS REGARDING THE ACOUSTICAL DETECTION OF BOILING IN THE PRESENCE OF CAVITATION. Saxe, R. F. (North Carolina State Univ., Raleigh. Dept. of Nuclear Engineering). Jun 1969. Contract AT(40-1)-3911. 29p. Dep. CFSTI.

Acoustic methods for detecting incipient boiling in reactor cores, both water- and liquid metal-cooled, were investigated for the purpose of devising a method by which the onset of nucleate boiling could be determined at a speed compatible with possible control action. Previous experiments on boiling noise and noise from cavitation are reviewed. The mechanics of bubble collapse, acoustic emission, and of light emission are discussed. The difficulties of distinguishing boiling bubble emissions and cavitation bubble acoustic emissions are enumerated. It is concluded that in both water-cooled and liquid metal-cooled systems with considerable subcooling and in the absence of cavitation noise, boiling may readily be monitored acoustically. When only moderate amounts of cavitation noise are present, acoustic pulse techniques are preferable to continuous wave techniques for acoustic monitoring. With large amounts of cavitation noise present, the use of a "relative time-of-arrival" method for distinguishing boiling noise from cavitation noise seems feasible. (L.C.L.)

**16773** (Y-1699) HYPFIL: A FORTRAN COMPUTER PROGRAM FOR THE INVESTIGATION OF PROCESS PARAMETERS IN SINGLE-STAGE HYPERFILTRATION PROCESSES. Griffith, W. L.; Keller, R. M.; Ebel, R. A.; Dillon, R. S. (Union Carbide Corp., Oak Ridge, Tenn. Y-12 Plant). 10 Feb 1970. Contract W-7405-eng-26. 127p. Dep. CFSTI.

A FORTRAN IV computer program was developed for the IBM 360 computer to solve a system of equations to simulate the hydrodynamic flow conditions in tubular systems (rectangular or circular) and to calculate relative water costs. The mathematical model includes the effect of concentration polarization and the dependence of membrane salt rejection on flux and salt concentration. Provisions have been made to simulate the hydrodynamic effect of turbulence promoters and to include allowance for brine disposal costs in the economic model. The inlet velocity and pressure, water recovery, and flow geometry can be optimized to calculate minimum water costs subject to inequality constraints on the independent variables. The optimized solution conforms to an upper limit placed on the product salt concentration and a lower limit on the Reynolds number. (auth)

**16774** TRANSIENT HEAT TRANSFER FROM A HOT NICKEL SPHERE MOVING THROUGH WATER. Walford, F. J. (Atomic Weapons Research Establishment, Foulness, Eng.). Int. J. Heat Mass Transfer; 12: 1621-5(Dec 1969).

The object of the work described was to identify the rapidly changing modes of boiling and to correlate these with variations in heat flux, so that any theoretical treatment of transient heat transfer from hot bodies could be founded on a correct physical model. (auth)

**16775** RADIANT HEAT TRANSFER MEASUREMENTS IN AN ANNULAR CAVITY BOUNDED BY ZIRCALOY-2 TUBES. Campanile, A.; Galimi, G.; Goffi, M.; Passavanti, G. (SORIN, Vercelli, Italy). Energ. Nucl. (Milan); 16: 775-80(Dec 1969).

Heat transfer experiments aimed at the determination of the rate of heat exchanged by radiation in an annular cavity bounded by Zircaloy-2 surfaces are presented. Data obtained for metallic as well as oxidized surfaces are tabulated. An attempt to evaluate total emissivity values starting from the reported measurements of the amount of heat transferred in the different conditions tested, is also described. (auth)

**16776** VOID FRACTION IN AN ANNULAR CHANNEL AT ATMOSPHERIC PRESSURE. Evangelisti, Roberto; Lupoli, Paolo (Centro di Studi Nucleari, Casaccia, Italy). Ing. Nucl., 10: No. 2, 19-36(Mar.-Apr. 1969). (In Italian).

The precise determination of the volumetric fraction of vapor in a water– steam two-phase mixture is of essential importance for the design of boiling water reactors and for a complete comprehension of two-phase fluid dynamics. The void fraction in a vertical annular channel with 500 mm length, 13 mm external diameter, and 7 mm internal diameter was studied under boiling conditions with thermal flux at atmospheric pressure. Data were reported for two values of the range and three thermal fluxes, either in the region of subcooled boiling and of mass boiling. The experiment devices and the method for the measurement of the $\gamma$ attenuation were described. In the test, plexiglass pieces of various dimensions were used to simulate the various void fractions. The results obtained on the $\alpha-\theta$ functions in the subcooled region were shown graphically and compared with theoretical calculations. The void fractions as a function of the thermal flux and the mass velocity were compared experimentally and theoretically. (J.S.R.)

**16777** PROBLEMS OF HEAT TRANSFER AND HYDRAULICS OF TWO-PHASE MEDIA. Kutateladze, S. S. Oxford; Pergamon Press Ltd. (1969). 499p. $19.00. (NP-tr-1870).

Translated by O. M. Blunn.

The theory of heat transfer and physical hydrodynamics of two-phase systems is discussed. A collection of 22 articles by different authors dealing with various aspects of boiling and condensation heat transfer and the flow of two-phase mixtures, is presented. (R.C.K.)

**16778** THE INITIAL VAPOR BUBBLE GROWTH ON A HEATED WALL DURING NUCLEATE BOILING. Sernas, V. (Rutgers–The State Univ., New Brunswick, N. J.); Hooper, F. C. Int. J. Heat Mass Transfer; 12: 1627-39(Dec 1969).

An experimental investigation of the initial vapor bubble growth on a horizontal, heated wall during saturated pool boiling is reported. Streak photography was adapted for the first time to the observation of bubble growth rates. When combined with high-speed framing photography this proved to be an effective technique for the observation of the initial growth of a bubble because the uncertainty in the zero time datum can be reduced to about 10 $\mu$sec. This compares with a correspondingly uncertainty of at least 100 $\mu$sec in previously reported works which used high-speed framing photography alone. Hemispherical bubbles were measured during the first 500 $\mu$sec following nucleation. The growth curves showed the liquid momentum effects were not significant beyond the first 50 $\mu$sec. For the time period between 50 and 500 $\mu$sec following nucleation, the data fitted very closely the one half power, $R = mt^{1/2}$, where R is the bubble radius, m the growth constant and t the time. The measured growth constant was compared with those predicted from five different analytical models, and was found to correspond closely to a model which postulated a thick microlayer of constant thickness underlying the bubble. "Thick" implied a sufficient thickness to delay the arrival of the temperature wave at the microlayer liquid–heated-surface interface until some time later than 500 $\mu$sec. (auth)

**16779** HEAT TRANSFER FOR A FLAT PLATE WITH LONGITUDINAL LAMINAR FLOW, WITH THE HEAT FLUX DISTRIBUTION $q_w \sim x^m$. Graeber, H. (CEN, Saclay, France). Int. J. Heat Mass Transfer; 12: 1605-20(Dec 1969).

Using similarity considerations, it is shown that in parallel flow along a flat plate, similar temperature profiles, i.e., locally independent Nusselt-numbers based on thermal boundary layer thickness, can only be expected for laminar flow and distribution of heat flux obeying the power law $q_w \sim x^m$. Using approximations the thermal boundary layer thickness and thus the Nusselt-number defined with the distance x from the leading edge of the plate can

be determined. Results are compared with Nusselt-numbers obtained by an exact procedure developed by Sparrow and Lin. Equations are deduced predicting the distributions of heat flux normal and shear stress parallel to the wall valid for both laminar and turbulent flow. (auth)

**16780** BOILING CRISIS IN LONGITUDINAL FLOW PAST ROD BUNDLES. Tolubinskii, V. I.; Mazka, S. A.; Vasil'ev, A. A. (Inst. of Engineering Thermophysics, Kiev). Heat Transfer - Sov. Res.; 2: 1-6(Jan 1970).

An estimate, obtained by analysis of Soviet and Western publications on the heat transfer crisis in rod bundles in longitudinal flow, of the possible effect of various geometric characteristics of multirod assemblies on the critical heat flux density is presented. (auth)

**16781** CONSIDERATIONS CONCERNING THE SECOND BURNOUT POINT. Torikai, Kinichi (Japan Atomic Energy Research Inst., Tokai, Japan); Akiyama, Mamoru. Nippon Kikai Gakkai Rombunshu; 35: 2273-7(Nov 1969). (In Japanese).

In usual pool boiling, the burnout point is determined by hydraulic limit for rapid exchange of vapor and cool liquid. When this hydraulic limit is removed by some means, attachment of vapor bubbles on the surface determines the maximum heat transfer, called the second burnout point. The vapor bubble attached to the surface develops a thin liquid film which is dried up with time. Areas of thin film and the dry surface were estimated and illustrated using experimental data. An increase in the dry area means a decrease in the effective area of heat transfer and this determines the second burnout point. The maximum heat transfer per unit area, limited by this mechanism, was estimated, using the available experimental data, to be about $10^7$ cal/$m^2$·h, that is, about ten times larger than that at the usual burnout point. The ratio of dry area to the total area is about 0.55. By removing the hydraulic limit, this point can be attained. (NSA of Japan)

**16782** HEAT TRANSFER IN LAMINAR FLOW OF BINGHAM PLASTIC FLUID WITH INTERNAL HEAT GENERATION IN CONCENTRIC ANNULUS. Michiyoshi, Itaru; Nakajima, Tsuyoshi (Kyoto Univ.). J. Nucl. Sci. Technol. (Tokyo); 7: 82-91(Feb 1970).

An analysis of the flow characteristics and heat transfer of a Bingham plastic fluid in laminar flow through concentric annuli is presented. The friction factor obtained for a given Hedstrom number in fully established flow varies with the radius ratios of the annular space and of the bounds of the plug region. The Nusselt numbers at the two wall surfaces in both fully developed and thermal entrance regions are calculated under the conditions of uniform internal heat generation and uniform but mutually differing heat fluxes at the two wall surfaces. Analytical results show that the Nusselt numbers become negative or infinite under certain thermal conditions at the walls. (auth)

**16783** MICROLAYER IN NUCLEATE POOL BOILING. Cooper, M. G. (Cambridge Univ., Eng.). Int. J. Heat Mass Transfer; 12: 895-913(Aug 1969).

Experiments are reported in which organic liquids underwent pool boiling at low pressure, forming large vapour bubbles on the surface of a heater plate consisting of glass or ceramic. The temperature at the surface of the heater was measured, leading to support for the hypothesis that a thin layer of liquid (the microlayer) forms beneath the vapour bubble. From the experimental observations it is possible to deduce the thickness of the microlayer, which can also be predicted from a simple theory for the hydrodynamics of the formation of the layer. Experiment and theory agree within ±25% for the limited cases available. The rates of growth of the bubbles are shown to be of the same order as the rates of evaporation from the microlayers, which can be expressed in analytic form under certain assumptions. A computer program for bubble growth allowing for the microlayer and other factors was developed and applied to two bubbles growing under widely different bulk temperatures. The predicted radii are within ±15% of those observed. The relative magnitudes of stresses due to inertia, surface tension, viscosity and gravitation are determined for a typical bubble, and discussed in relation to bubble shape and microlayer formation. It is stressed that these results may not apply to widely different conditions of boiling. (auth)

**16784** FACILITY FOR COOLING A HEATED MEMBER, MORE PARTICULARLY A NUCLEAR REACTOR FUEL ELEMENT. (to European Atomic Energy Community). British Patent 1,178,652. 21 Jan 1970. Priority date 26 Jul 1967, Germany.

A system of cooling a heated body by surface evaporation of a liquid is described. The upward sloping heated surface of the body incorporates upwardly extending adjacent capillary grooves. The upper end of the surface dips to an open reservoir for the liquid which has risen along the surface by capillary action. The liquid collecting tank has a heat sink or condenser for the vapor produced from the liquid flowing over the surface. (J.R.D.)

# Isotope Technology

*Refer also to abstract 16433, 16674, 16749, 16756, 16839, 16840, 17042, 17073, 17115, 17250, 17259, 18451, 18564, 18666, and 18667.*

**16785** (BNWL-1270) HANFORD $^{146}$Pm BURNOUT EXPERIMENTS. Sheppard, J. C.; Van Tuyl, H. H. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Jan 1970. Contract AT(45-1)-1830. 22p. Dep. CFSTI.

Hanford $^{147}$Pm, containing about 0.3 ppM $^{146}$Pm, was irradiated in a Hanford K-Reactor in an attempt to burn out the $^{146}$Pm present and thereby reduce the gamma dose rate to a level where $^{147}$Pm could be used in circulatory assist devices. The $^{146}$Pm content was reduced by a factor of two for the longest irradiation, which was less than the expected result. A cross section of 3500 b was found for $^{146}$Pm, compared to 8400 b found by Pinajian, which partially explains the low $^{146}$Pm burnout. The $^{146}$Pm cross section varied slightly with position in the target, suggesting resonance capture of epithermal neutrons. Explanations for the low burnout of $^{146}$Pm are examined and possible ways of further reducing the $^{146}$Pm content are suggested. (auth)

**16786** (GA-9763) SNAP-15A THERMOELECTRIC GENERATOR. Summary Report, July 1, 1968-June 30, 1969. (Gulf General Atomic, Inc., San Diego, Calif.). 22 Jan 1970. Contract AT(04-3)-167. 45p. Dep. CFSTI.

The activities of the SNAP-15A testing program for the period July 1968 through June 1969 are summarized. During this period twenty-five generators were continued on life testing and the performance data were analyzed. One of the generators with more than 5 years lifetime was removed from test and examined for compatibility evaluation. Examination of the interior components of the generator showed they were in excellent condition after operation in air for over 4 years. The changes in performance of all the generators due to causes other than fuel depletion have been less than 1% per 10,000 hours. A life testing program for the remaining twenty-four generators is being continued. Several electrically heated generators will have exceeded 5 year lifetime at the end of FY 70. (auth)

**16787** (HIT-345) SPHERICAL CAPSULE TECHNOLOGY PROGRAM. Quarterly Progress Report, April 1, 1968-June 30, 1968. (Hittman Associates, Inc., Columbia, Md.). Apr 1969. Contract AT(29-2)-2475. 54p. Dep. CFSTI.

Progress on the development of spherical radioisotope heat source fuel capsules is reported. The following items were accomplished: heat sources were sized for both finned and stagnation designs using both bare foam insulation and ceramic foam-metal composites in a thermal switch mode of operation; a non-vented heat source was evaluated for its ability to contain helium during reentry; the effect of outer graphite shells on the reentry performance was evaluated; terminal trajectories were computed for a spherical heat source with and without spin-up fins; thermal switch testing was performed on silica foam-silver composites; mechanical and thermal (using an electrical analog) properties of ceramic foam-silver composites were measured; weldability studies were performed on ten promising superalloy material capsule candidates; ten superalloy materials were evaluated for oxidation characteristics at 2300°F; data were generated on the tensile properties of ten superalloys in the unaged and aged conditions (290 hours at 1500°F at 70°F and 1800°F) and additional 1000 hour data for the four most promising superalloys were obtained; and hastelloy-N shells were fabricated for test in the impact facility. (auth)

**16788** (PPAD-665-E) STUDIES OF SHORT-LIVED RADIOACTIVE ISOTOPES WITH ON-LINE ISOTOPE SEPARATORS. Naumann, R. A. (Princeton-Pennsylvania Accelerator, Princeton, N. J.). 8 Sep 1969. Contract AT(30-1)-2137. 64p. (CONF-690818-10). Dep. CFSTI.

From International Conference on Radioactivity in Nuclear Spectroscopy, Nashville, Tenn.

Presently a number of laboratories are engaged in the study of the radioisotopes of gaseous or easily volatilized elements. These studies involve gaseous transfer from a target to the ion source of an on-line isotope separator. These projects are reviewed and results are presented for isotopes with half lives in the second range. The extension of the technique to even shorter lived isotopes of a wider group of elements involves isotopes

production by bombarding targets which are located within the ion source of the mass separator. (30 references) (J.C.W.)

**16789** (ORNL-tr-2227) PRODUCTION OF RADIOACTIVE ISOTOPES. Knoll, Peter. Translated by Lynda H. Kern (Oak Ridge National Lab., Tenn.), from Chem. Tech. (Leipzig); 12: 25-8(1960). 14p. Dep. CFSTI.

An abstract of this paper, prepared from the original language, appeared as NSA 14: 10904.

**16790** (TID-25185) DISCHARGE MEASUREMENTS USING THE RADIOISOTOPE VELOCITY, INTEGRATED SAMPLE, DILUTION, AND TOTAL-COUNT METHODS AT FLATIRON POWER AND PUMPING PLANT, COLORADO-BIG THOMPSON PROJECT. Schuster, J. C.; Hansen, R. L. (Bureau of Reclamation, Denver, Colo. Office of Chief Engineer). Jul 1969. 39p. Dep. CFSTI.

Radioisotope techniques and equipment are being developed to improve methods for measuring flow rate in high-head turbines and pumps. A series of discharge measurements were made in 1968, at Flatiron Powerplant near Loveland, Colo., to evaluate techniques and equipment. Measurements were made on a 6000-ft-long, 6-ft-dia penstock at a discharge of 300 cfs. Thirty-seven injections of radioactive bromine-82 were made for discharge measurements by the velocity method, 17 for the integrated-sample method, and 8 for the dilution method. These injections enabled computation of 33 discharges by the velocity method, 26 by the integrated sample, 45 by the dilution method, and 34 by the total-count method. A 4-point injection system, 45 deg from the vertical and horizontal center lines of the pipe, was used for most measurements. Mixing lengths ranged from 36 to 919 pipe diameters. Mixing lengths of 100 pipe diameters produced the same order of accuracy as mixing lengths of 919 diameters. Studies are continuing to increase measurement accuracy using pipe lengths as short as 30 pipe diameters. (auth)

**16791** ISOTOPES AND RADIATION. Nucl. News; 13: 45-8(Jan 1970).

Radioisotopes are currently produced by private industry or the AEC by cyclotron, reactor irradiation, and by processing of high-level wastes, as well as refining from natural sources. The many uses of californium-252 have been publicized. The AEC produces various radioisotopes from the waste streams at the Richland chemical separations plant, principally strontium-90, cesium-137, and promethium-147. AEC produces tritium which is used in self-illiminating devices. Activities involving radioisotopes and irradiation are thermoelectric generators, commercial material and food processing, medical treatment and diagnosis, high-energy physics, and environmental research and pollution control. Curing of surface coatings and irradiation of wood–plastics are promising uses of isotopes. Medical applications are also discussed. Watershed management problems are being studied with a snow density gauge. AEC actions and rule changes in 1969 are discussed. Construction on facilities to study high-energy physics is continuing at the National Accelerator Laboratory and Argonne National Laboratory. (J.C.W.)

**16792** NEW RADIOACTIVE LIGHTNING PROTECTION. Marsicanin, B.; Radosavljevic, Z. (Boris Kidric Inst. of Nuclear Sciences, Belgrade). Isotopenpraxis; 5: 399-403(Nov 1969).

The protective zone of conventional lightning rod (Franklin's rod) is very small. In order to enlarge it, a greater number of such lightning rods can be set up or the Faraday cage employed. In the case of high objects or those covering large areas, this kind of protection is not economical. The use of radioactive sources for air ionization around the lightning rods enlarges the protective zone considerably. A comparison is given of the radioactive lightning rod, which uses alpha emitters and are widely employed in some countries of western Europe and Africa, and the proposed radioactive lightning rod which uses a gamma radiation source. (auth)

**16793** URANIUM ENRICHMENT. Avery, D. G. (United Kingdom Atomic Energy Authority, Risley, Eng.). Phys. Bull. (London); 21: 17-21(Jan 1970).

The principal technical features of the gaseous diffusion technique, the gas centrifuge method, and the separation nozzle process used for enrichment of the fissile $^{235}U$ content of natural uranium and the problems that have to be solved in bringing these techniques to the stage of economic industrial exploitation are discussed. (UK)

**16794** GERMAN IMPORT AND EXPORT OF RADIONUCLIDES, 1968. Atomwirt., Atomtech.; 14: 611-12(Dec 1969). (In German).

**16795** EXPERIMENTAL STUDY ON THE GASEOUS DIFFUSION PROCESS BY MEANS OF A 10-STAGE CASCADE. Higashi, Kunio; Doi, Hideo; Saito, Toru (Kyoto Univ.). Energ. Nucl. (Milan); 17: 98-103(Feb 1970).

In order to study the static and dynamic characteristics of the gaseous diffusion process, a laboratory-scale crusade with 10-stages was built. This was a triangular cascade (cut: 0.5) consisting of 55 separating elements and 9 compressors. The porous membranes used were made of sintered nickel and shaped in 50 mm Ø disc-type. The excellent self-controllability of the gaseous diffusion cascade has been confirmed experimentally using it without any control system. The disagreement between theoretical and experimental results is discussed briefly with respect to equilibrium time. (auth)

**16796** DEFINITION OF THE WORKING CONCEPT OF ISOTOPIC SEPARATION AND URANIUM ENRICHMENT STANDARD TABLE. Sugier, A. Bull. Inform. A.T.E.N. (Ass. Tech. Energ. Nucl.), No. 77, 42-4(May-June 1969). (In French).

The working concepts of isotopic separation and enrichment standards for uranium are defined. The basic characteristics of different types of cascades are reviewed. A mathematical study was made of the phenomena of isotopic separation. (J.S.R.)

**16797** THERAPEUTIC RADIOACTIVE SOURCE AND METHOD OF MANUFACTURE THEREFOR. Lawrence, D. C. Canadian Patent 830,573. 23 Dec 1969.

A radioactive seed is described for use in radiation therapy comprising a sealed container adapted for perforate injection. The container is formed of a non-toxic material such as stainless steel or titanium compatible in human fluids. A therapeutic amount of soft x-ray emanating material namely $^{125}I$, $^{131}Cs$ or $^{103}Pd$ is distributed uniformly within the container so that the radiation pattern is uniform in all directions about the container which has a low absorption for soft x-rays. It is not intended that the seed should be removed after the active period of between 8 to 100 days. The total length of the seed is about 4 mm and its cross section small enough for injection from a hypodermic needle. Characteristic radiation is between 20 and 100 keV and provision is made in the construction for shielding $\alpha$ and $\beta$ radiations. Means are provided for blocking the transmission of photographic x-rays using a solid ball or fine wire. Construction details and materials for these small seeds are given. (F.S.A.)

**16798** STANDARDIZATION OF $^{137}Cs$ GAMMA-RAY SOURCES IN TERMS OF EXPOSURE UNITS (ROENTGENS). Loftus, T. P. (National Bureau of Standards, Washington, D. C.). J. Res. Nat. Bur. Stand.; 74A: 1-6(Jan-Feb 1970).

Cesium-137 gamma sources, which have been proposed by the Public Health Service as a substitute for radium in the treatment of malignant diseases, require suitable calibration if consistency is to be achieved in radiation treatment. Several $^{137}Cs$ sources were calibrated using a graphite cavity ionization chamber in an open-air geometry. The contribution of scatter from the room surfaces was calculated and the source measurements corrected for this effect. A large-volume aluminum-walled ionization chamber was designed and fabricated for use in routine calibrations. This chamber will be used as a means for intercomparison of the source to be calibrated with one of the standards. (auth)

**16799** AN OUTLOOK ON THE PROSPECTS FOR URANIUM ENRICHMENT IN THE U.S.A. Nichols, K. D. (Atomic Industrial Forum, Inc., New York). pp 143-52 of Utilizzazione del Combustibile Nucleare. Roma; Comitato Nazionale Energia Nucleare (1969).

From 10th International Nuclear Energy Conference, Milan, Italy. See CONF-681219.

Costs and production capacity of existing uranium enrichment facilities in the U. S. and the prospects for these facilities meeting U. S. and international requirements are discussed. The prospects for increasing the capacity of existing facilities in the 1970's by cascade improvements and plans for preproducing enriched material for future requirements are presented. The conclusions and recommendations made by the Atomic Industrial Forum Study Committee on Private Ownership and Operation of Uranium Enrichment Facilities, feasibility and economic considerations of private ownership, prospects for additional U.S. enrichment facilities to meet future U.S. and international requirements, and technical and economic considerations pertaining to new facilities are summarized. (auth)

**16800** PROSPECTS FOR A EUROPEAN ISOTOPE ENRICHMENT PLANT. Michaelis, H. pp 153-66 of Utilizzazione del Combustibile Nucleare. Roma; Comitato Nazionale Energia Nucleare (1969).

From 10th International Nuclear Energy Conference, Milan, Italy. See CONF-681219.

The countries of the European Community obtain their uranium supplies only from the United States. The development of nuclear energy in the world suggests that the capacity of the present enrichment facilities will be totally absorbed before the end of the seventies, and that therefore new uranium enrichment plants will have to be installed. According to the latest estimates and predictions as to plant types, the demand on separation plants by Community power plants installed by 1980 will amount, already in 1978, to 4 to 6 million kilograms/year. The Community's energy policy envisaged ways of increasing the margin of supply by reducing requirements, diversifying the sources and improving the conditions of foreign supplies, and increasing the self-supply by installing in the Community area enrichment facilities. The monopoly in fact held by the USAEC and the planned transfer of the property of facilities to private US corporations create serious problems for the European users. Many advantages are offered by European enrichment plants but authorities are concerned with the solution of the choice of the process, the economic parameters, the status of the enterprise and the sales policy. Preliminary data available to the Committee suggest that in the European case the UTS/kg cost could be slightly higher than the $26 charged by the AEC. (J.C.W.)

**16801** PLANNING FOR FUTURE ENRICHMENT PLANTS. Allday, C.; Avery, D. G.; Kehoe, R. B. pp 167-79 of Utilizzazione del Combustibile Nucleare. Roma; Comitato Nazionale Energia Nucleare (1969).

From 10th International Nuclear Energy Conference, Milan, Italy. See CONF-681219.

The United Kingdom and European requirements for enrichment and the plans for meeting them are summarized. A number of factors which arise in optimizing the installation of plant and its subsequent operation are discussed. The problems arising in considering the diffusion nozzle and centrifuge separation processes are considered. (auth)

**16802** GROWTH POTENTIAL FOR ISOTOPE APPLICATIONS IN ENVIRONMENTAL AND OCEAN SCIENCES. Smith, D. B. (Wantage Research Lab., Eng.). pp 218-25 of The International Conference on Constructive Uses of Atomic Energy. /Farmakes, Ruth (ed.). Hinsdale, Ill.; American Nuclear Society (1969).

From International Conference on the Constructive Uses of Atomic Energy, Washington, D. C. See CONF-681101.

The growth potential for isotope applications in the environment field which includes hydrology, meteorology, and oceanography are briefly reviewed. In hydrology the radioisotope uses of special interest include low-level tritium tracing of ground water, $^{14}C$ measurements, and ground water stratification measurements. In meteorology radioactive tracers will be important for examining large scale tropospheric air movements, for studying atmospheric pollution, and for defining the structure of storms such as hurricanes and cyclones. Radioisotopic tracer techniques are important in oceanography to measuring sediment bed movements, water circulation, and coastal water pollution. (L.C.L.)

**16803** THE NEXT DECADE FOR ISOTOPE AND RADIATION POWER SOURCES. Reiffel, Leonard (Instructional Dynamics Inc., Chicago). pp 228-37 of The International Conference on Constructive Uses of Atomic Energy. /Farmakes, Ruth (ed.). Hinsdale, Ill.; American Nuclear Society (1969).

From International Conference on the Constructive Uses of Atomic Energy, Washington, D. C. See CONF-681101.

Predictions are made on the uses of radioisotope-fueled thermal generators (RTG) in the next decade. The design and operation of several existing RTG's for use undersea, in space, and in circulatory assist units, etc., are presented. (L.C.L.)

**16804** PROCESS FOR COVERING RADIO-ACTIVE BALLS WITH METAL, AND RADIO-ACTIVE BALLS COVERED WITH METAL BY THIS PROCESS. Cardis, Raymond. British Patent 1,183,159. 4 Mar 1970. Priority date 7 Nov 1967, Switzerland.

A method of producing easily handled radioactive sources is described. The material is in the form of balls covered with metal designed to render the surface electrically conductive. The balls thus coated are enclosed in a metal shell obtained by deposition of a series of layers. The balls produced in this manner have good mechanical strength and do not dissolve in water. (J.R.D.)

## Materials Testing

*Refer also to abstracts 16754, 16787, 16819, 16845, 16862, 17192, 17280–17286, 17288–17290, 17293, and 17326.*

**16805** (CONF-690910–, pp 533-50) SOME APPLICATIONS OF NEUTRON RADIOGRAPHY IN IRRADIATION TESTING TECHNOLOGY. Ray, J. W. (Battelle Memorial Inst., Columbus, Ohio).

The efficiency of neutron radiography in providing high quality radiographs of highly radioactive specimens has led to its use in irradiation testing technology at several installations. It has been used routinely in conjunction with irradiation programs at the Battelle Research Reactor (BRR) for about four years. The principal applications of neutron radiography in determining fuel specimen dimensional changes periodically during irradiation and in examination of experimental assemblies to determine the integrity of key components are described. (auth)

**16806** (CONF-690910–, pp 540-50) NEUTRON RADIOGRAPHIC INSPECTION OF IRRADIATED SNAP FUEL. Hillig, O. R. (Atomics International, Canoga Park, Calif.).

Post-irradiation test samples of SNAP reactor fuel elements have been nondestructively examined using neutron radiography. The results of the neutron radiographic (N-ray) examinations have been correlated with measurements made using standard hot cell destructive testing. Fuel swelling, cracking, and decomposition were readily discernible in a series of N-ray tests. Further examination of the N-rays revealed that information was available to determine hydrogen content in the uranium-zirconium hydride fuel and that the gap between the fuel and the cladding could be measured. Additional tests were performed using nonirradiated samples of known hydrogen content and known gaps between fuel and cladding to establish procedures for neutron radiography of fuels and to provide standards for comparison with future tests. Hydrogen differences of 0.02 H/Zr atom ratio can be determined from the radiograph using known standards for comparison and gaps between cladding and fuel can be measured to 0.001 inch accurately. (auth)

**16807** (ORNL–4480, pp 114-17) NONDESTRUCTIVE TESTING TECHNIQUES FOR LMFBR. (Oak Ridge National Lab., Tenn.).

From Fuels and Materials Development Program Quarterly Progress Report.

New methods and equipment are being developed for nondestructively evaluating materials or components related to the LMFBR program. Electromagnetic-induction, ultrasonic, and penetrating-radiation test methods are being developed. The design of a new kind of eddy-current instrument for determining the depth of flaws beneath the inspection surface was initiated. Preliminary studies were made on the use of optical schlieren techniques on welds to aid the development of ultrasonic inspection techniques. Two sets of samples of stainless steel containing varying degrees of cold work were prepared. Preliminary measurements of magnetic permeability by an electromagnetic-induction technique on sheet specimens show good correlation. (auth)

**16808** (ORNL–4480, pp 266-73) NONDESTRUCTIVE TESTING. (Oak Ridge National Lab., Tenn.).

From Fuels and Materials Development Program Quarterly Progress Report.

Techniques and equipment are being developed for nondestructive testing of materials and components. The major emphasis has been on methods involving eddy currents, ultrasound, and penetrating radiation. Analytical work on electromagnetic phenomena is reported in which solutions to integral equations for additional configurations of coil and conductor were developed, including the cases of a coil between a number of conducting plates and a coil encircling two concentric, spherical shells. Research directed toward improved accuracy of equations for cases of defects in conductors is reported. Improvements were made to a schlieren system that increase the sensitivity for pulsed operation. Sequences can be recorded on video tape or motion picture film. A system of ultrasonic frequency analysis is being used to study reflections from flat, circular reflectors as a function of several variables, including specimen material and the size and orientation of the reflector. The capability for making and measuring precision reference notches through use of Ta tools and improved tool holders was increased. A preliminary study was made to determine the capability of a scanning system for x-ray attenuation to measure variations in graphite density. Data is being accumulated on the use of $^{241}Am$ and $^{147}Pm$ for measuring the thickness of cladding by methods based on radiation scattering. (auth)

**16809** (RT/ING–(69)10) TECHNIQUE OF GAMMA DENSITOMETRY ON IRRADIATED FUEL SAMPLES. Cesarano, C.; Cochi, C. (Comitato Nazionale per l'Energia Nucleare, Rome (Italy)). 28 Mar 1969. 28p. (In Italian). Dep. CFSTI (U. S. Sales Only).

A method is described concerning the determination of variation

of density along the axis of an irradiated fuel specimen. This method is based upon the attenuation of gamma radiation when it passes through any material, as the fraction of radiation absorbed or scattered is a function of the density, as well as thickness and mass absorption coefficients of the specimen. The principle is to detect a collimated beam of gamma rays, emitted by a strong cobalt source and passed through the fuel sample, and to record the variation of intensity of the beam as the specimen is scanned. Because of the gamma activity of the fuel itself, which would mask that from the source, it is necessary to discriminate the gamma ray energy of the cobalt source. This is accomplished electronically. Collimation ensures that scattered and absorbed radiations are not detected, increasing sensitivity. (auth)

**16810** TRACK REGISTRATION ALPHA AUTORADIOGRAPHY. Davies, John H.; Ruiz, Carl P.; Storms, Howard A. (to General Electric Co.). U. S. Patent 3,493,751. 3 Feb 1970. Filed 17 Jun 1966.

A process for producing autoradiographs of alpha-particle emitting objects is disclosed. Typically, a sheet of track-registration material is placed adjacent to an alpha emitting object, maintained there for suitable period, and then treated with an etchant. The etchant selectively dissolves damage tracks along the parts traversed in the material by alpha particles. The tracks produce a visible image corresponding to alpha-emitting portions of the objects. (Offic. Gaz.)

**16811** RADIOGRAPHIC EXAMINATION OF IRON-CONTAINING OBJECTS USING SUBTHERMAL NEUTRONS. Barton, John Penrose. (to United Kingdom Atomic Energy Authority). U. S. Patent 3,496,358. 17 Feb 1970. Priority date 13 May 1965, Great Britian.

An object, the predominant metal of which is iron, is radiographically examined with subthermal neutrons by forming a beam of neutrons having an energy less than the energy at which there is cut-off of the coherent scattering effect on neutrons in iron, directing that beam of neutrons at the object to be examined, and detecting the neutrons which pass through that object. In this manner, iron containing objects having a thick cross section, can be effectively radiographically examined. (Offic. Gaz.)

**16812** NEUTRON RADIOGRAPHY. Brit. Med. J.; 4: 125 (18 Oct 1969).

Possible use of neutron radiography is considered. Since neutron absorption often varies between neighboring elements in the periodic table or even between different isotopes of the same element, neutrons offer the possibility of better discrimination in some circumstances than x rays. Neutron radiographs lack the contrast and resolution of x-ray images but have some distinctive features, for bone shadows are virtually absent and air-filled cavities are easily detected. Though fast neutrons can penetrate the body without difficulty, they present problems of radiation exposure. They are readily available from portable accelerators, and useful quantities of $^{252}Cf$ (an isotope with a high output of neutrons) will soon be available. But since existing photographic techniques are too insensitive for fast-neutron radiography at a dose acceptable to the patient, a radically new method of visualization is needed. Even then the technique is likely to find its main use when air (or nitrogen) can be introduced as a contrast medium or when the difference in hydrogen content between adjacent tissues can be exploited. (BBB)

**16813** NEW NON-DESTRUCTIVE TESTING TECHNIQUE: NEUTROGRAPHY. PART I. Barton, M. M.; Boutaine, J. L.; Corompt, P. (CEA-CENG, Grenoble, France). Microtecnic (Lausanne); 23: 299-302(Jul 1969).

X-ray and gamma radiography are now supplemented by "neutrography." Whereas the first two techniques mentioned permit examination of materials of high atomic number and density, in a low-density matrix, neutrography, which in many cases results in the inverse effects, permits the examination of large thicknesses of dense metals, such as lead, steel or uranium, or to distinguish between two materials of similar atomic number, tungsten and tantalum for example. It even facilitates photography of highly radioactive materials. U. S., British and Japanese research centres have for several years now been trying to simplify neutrography, so as to facilitate its introduction in factories or on sites. Whereas at first the only neutron sources were nuclear reactors, nowadays accelerators and isotope sources are also available. Neutrography is equally applicable to the study of brazed joints and hydrogenated materials and the examination of inaccessible cracks. It will certainly also find applications in medicine and biology. Although its results are novel, neutrography is sufficiently closely related to radiography that anybody experienced in the latter can readily adapt to this new technique. (auth)

**16814** THEORETICAL–EXPERIMENTAL INVESTIGATIONS IN THE USE OF GAMMA SCANNING FOR IRRADIATED REACTOR FUEL ELEMENT BURNUP. Zanchi, Franco (Univ., Rome). Ing. Nucl.; 10: No. 5, 39-62(Sep-Oct 1969). (In Italian).

The general methods used in determining irradiated-fuel characteristics are described. Gamma scanning techniques are discussed and methods of reducing gamma-scan data are considered. Application of gamma-scanning techniques to both PWR and BWR fuel elements is illustrated and some results are tabulated. Typical gamma spectra are shown graphically. 41 references. (M.L.S.)

**16815** CRYOGENIC TEMPERATURE IRRADIATION TESTING. Coombe, J. R.; Shogan, R. P. (Westinghouse Electric Corp., Pittsburgh). Cryog. Ind. Gases; 5: No. 2, 21-5(Feb 1970).

Radiation testing equipment and procedures for NERVA materials at cryogenic temperatures are described. The tests were conducted at the Ground Test Reactor using liquid nitrogen refrigerant at about 140°R. Materials were also tested at 540, 440, 340, and 240°R. (J.R.D.)

## Radioactive Material Handling

*Refer also to abstracts 16675, 16738, 16741, 16742, and 16758.*

**16816** (KFK–1101) EFFECTIVITY AND COST OPTIMIZATION OF SAFEGUARDS SYSTEMS. PART II. Avenhaus, R.; Gupta, D. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Angewandte Reaktorphysik). Aug 1969. 34p. (CONF-690826–1). Dep. CFSTI (U. S. Sales Only).

From Conference on Systems Analysis, Vienna, Austria.

The method for defining the effectiveness of safeguards systems is developed which does not require any prior knowledge of the relation between probability of detection and the amount assumed to be diverted. It requires a prior knowledge only of the measuring errors and other technical conditions, which may influence a diversion. This method also gives a criterion according to which the utilization of safeguards budget can be optimized. A number of other conclusions can be drawn based on the analysis given. The effectivity defined is for a single nuclear facility. For developing the concept of effectiveness for a safeguards system covering a number of facilities or a fuel cycle, the fact that fissile material will have different values in different facilities (effective kgs), will have to be taken into consideration. The definition of effectivity is based on the "detection" in case of a diversion. However, the question of "prevention" has also been touched by introducing the concept of critical time $t_c$, which compels an inspection authority to take an inventory and complete a material balance before a certain time has lapsed. This point can be further emphasized by optimizing the relation p/t. In that case optimization of $\Sigma$ alone, as has been done here, will not help. In a number of other cases also (for example, if the variance for MUF losses V were not normally distributed, or in case the diversion was assumed to be spread over the whole year etc.), minimization of $\Sigma$ alone will not give the optimum probability of detection. In such cases the probability of detection which is independent of $m_0$ might be a better value to optimize. Considerable amount of further work is required to solve still open problems in connection with the effectivity of safeguards system. (auth)

**16817** (MLM–1714) NUCLEAR CRITICALITY SAFETY OF DOT SPECIAL PERMIT NO. 6000 PACKAGE FOR LARGE QUANTITIES OF FISSILE WASTE MATERIAL. Wolfe, Richard A. (Mound Lab., Miamisburg, Ohio). 20 Feb 1970. Contract AT-(33-1)-Gen-53. 13p. Dep. CFSTI.

A criticality safety evaluation was made for the Department of Transportation (DOT) Special Permit No. 6000 Package when containing quantities of fissile waste material ($^{238}Pu$, $^{239}Pu$, $^{233}U$ and $^{235}U$) up to 200 g. The calculations were performed by the density analog technique which provides conservative results when proper assumptions are applied. The criticality control, i.e., fissile class, that should be used when shipping fissile waste material in any of the three DOT 6000 shipping containers was established. (auth)

**16818** (ORNL–4473) ENCAPSULATION OF NOBLE FISSION PRODUCT GASES IN SOLID MEDIA PRIOR TO TRANSPORTATION AND STORAGE. Clark, W. E.; Blanco, R. E. (Oak Ridge National Lab., Tenn.). Feb 1970. Contract W-7405-eng-26. 38p. Dep. CFSTI.

The encapsulation of fission product gases in various solid media is being considered at ORNL as a possible method for immobilizing these gases during interim storage, transportation, and ultimate storage. This type of immobilization would decrease the

possibility of the uncontrolled release of such materials. In the study reported here, three media—glass, plastics, and metals—were investigated for use in encapsulation. The combination of known techniques and extrapolated test results showed that gas loadings of up to 50% of those currently obtained in cylinder storage are obtainable by using either pressurized steel bulbs or molecular sieves in a matrix of epoxy resin. Loadings of up to at least 7.5% should be obtainable by direct dispersion of the gases in glass. Other possible encapsulation methods were also considered, and the advantages and limitations of each are discussed. The volumes of fission product gases produced in reactors fueled with $^{239}Pu$ (LMFBR), $^{233}U$ (MSBR), and $^{235}U$ (PWR-1) were estimated. It was assumed that tritium and iodine will be separated from the noble gases and will be converted to stable solid compounds for permanent storage. The combined volumes of krypton and xenon are considered to be 25.0, 27.6, and 30.9 liters (STP) per 1000 Mwd for the LMFBR, MSBR, and PWR-1, respectively. The volumes of xenon and krypton generated daily in a 5-metric-ton-per-day reprocessing plant for LMFBR fuel represent about 81% of the capacity of a standard gas cylinder. If the relatively short-lived xenon were separated from krypton, the daily volume of krypton would occupy less than one-tenth the volume of a standard gas cylinder. Basic technology is already available for encapsulating radioactive gas in solid matrices to yield a final product containing 25 to 50%, by volume, of the gaseous component. Engineering and economic evaluations are needed to determine whether the added safety factor obtained by immobilizing such a gas warrants the additional expense. (auth)

**16819** (ORNL-NSIC-61) HIGHWAY VEHICLE IMPACT STUDIES: TESTS AND MATHEMATICAL ANALYSES OF VEHICLE, PACKAGE, AND TIEDOWN SYSTEMS CAPABLE OF CARRYING RADIOACTIVE MATERIAL. Kelly, O. A.; Stoddart, W. C. (Oak Ridge National Lab., Tenn.). Feb 1970. Contract W-7405-eng-26. 137p. Dep. CFSTI.

Four vehicle impact tests were conducted in February through November of 1966 at the Aberdeen Proving Ground as part of an initial study to develop test and instrumentation techniques and to acquire quantitative data on nuclear material transport systems that might be used to describe the dynamics of transportation accidents. The impact tests were performed with three different combinations of truck tractors and semitrailers and two types of cargo. A 350-ton barrier was constructed at the end of a paved road and the remotely operated test vehicles were impacted against it at various velocities. The tests were executed successfully, but the instruments installed on the tractors for quantitative measurements were damaged prior to conclusion of the impact phenomena because of the inherent weakness of the tractors. Photographic measurements provided the most meaningful description of the dynamic behavior of the transport systems during the impact tests. The mathematical model developed in conjunction with these tests did not accurately describe the actual behavior of the vehicles during impact. Even though all the desired quantitative data were not obtained, sufficient structural and transportability data were gained to assure a positive approach for evaluating the dynamics involved in future impact tests. (auth)

**16820** (TID-25357) QUALIFIED UMPIRE LABORATORIES. (Office of Safeguards and Materials Management (AEC), Washington, D. C.). 1 Feb 1970. 5p. Dep.

A program was undertaken to determine the qualification of U.S. commercial and foreign laboratories to serve as umpires in AEC transactions involving plutonium and uranium materials. Qualification was based on a demonstrated ability to analyze the different materials for the various specification categories. The period of qualification is to extend for two years after which requalification will be required. The laboratories which have qualified for the materials covered to date for the various specification categories are tabulated. (L.C.L.)

**16821** TESTING A TRANSPORT CASK FOR UNIRRADIATED NUCLEAR FUELS. Kurzmann, H. (Bundesanstalt fuer Materialpruefung, Berlin); Pfeifer, W. Atomwirt., Atomtech.; 14: 578-81(Dec 1969). (In German).

A cask for the transport of unirradiated uranium and plutonium fuel elements in the form of oxides is described. It consists of an external steel container with 1.5 mm thickness and an internal steel container with 4 mm thickness. The space between the two containers is filled with insulating material as protection against fire and shock. In accordance with regulations for the safe transport of radioactive materials, as established by the IAEA, the cask was tested for leakage, for shock resistance by dropping from a height of 9 m, and for fire resistance by being exposed to 800°C over a period of 30 minutes. The designed cask passed all prescribed tests. (H.B.G.)

**16822** METHOD OF REMOVING RADIOACTIVE COMPONENTS FROM A STREAM OF GAS. (to Ceag Concordia Elektrizitats-AG). British Patent 1,178,953. 28 Jan 1970. Priority date 19 Apr 1967, Germany.

A method is given for removing methyl bromide labeled with $^{82}Br$ from a stream of gas. The radioactive bromine compound is passed through an activated carbon support impregnated with potassium bromide. A mixture of hydrocarbon is used as the carrier gas for the labeled methyl bromide. (J.C.W.)

**16823** METHOD FOR PREVENTING THE PRESSURE INCREASE INSIDE A NUCLEAR FUEL CONTAINER. Hiruta, Y. (to Hitachi Ltd.). Japanese Patent 1968-875. 12 Jan 1968.

A method is given for storing and transporting a spent or damaged fuel rod. The container with the irradiated fuel rod is filled with water, and a flexible ball containing a gas is placed in the water to absorb the pressure increase in the nuclear container. (NSIC)

**16824** TRANSPORTATION OF FUELS AND ALLIED PROBLEMS. Scalliet, R.; Trousson, M. pp 357-70 of Utilizzazione del Combustibile Nucleare. Roma; Comitato Nazionale Energia Nucleare (1969).

From 10th International Nuclear Energy Conference, Milan, Italy. See CONF-681219.

Since the transport of radioactive materials may endanger the public environment, it is normal for such activities to be subjected to strict regulations aimed at guaranteeing safety by rules of a mainly technical nature applicable both to the packing of the materials being transported, the containers needed and the methods of transport. In this respect, the International Atomic Energy Agency (IAEA) in Vienna has been an especially effective driving force by drawing up recommendations which are used as a working basis by international organizations and national authorities in preparing mandatory regulations. In view of the fact, however, that the experience gained in the transport of radioactive materials is not yet so great that exhaustive knowledge of all the problems involved might be claimed, it is understandable that certain difficulties in applying the regulations should be experienced by design offices entrusted with designing and proposing packaging methods, shippers, carriers and lastly the competent authorities called upon to grant the required permits and authorizations. This is why the Euratom Commission has commissioned theoretical and experimental studies aimed at checking the basis of certain technical requirements, clarifying their methods of application and prompting proposed amendments or additions to their content or phrasing. Special attention has been given to the transport of irradiated fuels, the work carried out opening prospects of savings both in the field of transport proper and of chemical reprocessing. (auth)

## Vacuum Engineering

*Refer also to abstracts 16928, 17268, and 18346.*

**16825** REVIEW OF THE INDUSTRIAL APPLICATIONS OF VACUUM TECHNOLOGY. II. Espe, W. Vakuum-Tech.; 18: 179-89(Oct 1969). (In German).

The main applications of vacuum technology in industry are described and illustrated by numerous photographs and diagrams. The list of uses includes: incandescent lamps, high vacuum discharge tubes, gas- or vapour-filled discharge valves, television tubes, light producing gas- or vapour-filled low and high pressure discharge tubes, photoelectric cells, particle accelerators, vacuum-metallurgy, electrical and chemical applications, production of thin films in vacuo, and space simulation techniques. The importance of vacuum technology in modern industry is stressed. (auth)

**16826** REPORT ON A NEW ULTRAHIGH-VACUUM COATING PLANT. Flecher, Pierre (Institut fuer Experimentelle Kernphysik, Karlsruhe, Ger.). Vakuum-Tech., 18: 59-63(Apr 1969). (In German).

A new ultrahigh vacuum plant has been developed for coating large objects with superconductors by evaporation with a pressure of $10^{-10}$ torr. This apparatus is a synthesis of the requirement in the ultrahigh vacuum method of a vacuum free of oil, and a mechanical construction which is distinguished by simple operation, little maintenance, and very good protection against air leaks. The ultrahigh vacuum pump system consists of two Pfeiffer-Turbomolekular pumps connected in series and a cryopanel; with this arrangement of the two pumps, the theoretical partial pressure of hydrogen can be lowered to $10^{-13}$ torr. (auth)

# INSTRUMENTATION

## Radiation Detection Instruments

*Refer also to abstract 16697.*

### General Detectors and Monitors

*Refer also to abstracts 16810, 16939, 17042, and 18698.*

**16827** (AD-488329) PHOTOGRAPHIC AND MECHANICAL PROPERTIES OF NUCLEAR RESEARCH EMULSIONS. Bauer, Kenneth H.; McCulloch, James M.; Rambo, Rex H. (Naval Postgraduate School, Monterey, Calif.). May 1966. 50p. CFSTI. Thesis.

The effects of heating Ilford types G and K emulsion prior to exposure or processing were studied. Samples were heated at 55 to 60C for times up to 16 days, and other samples were assembled into stacks in which a temperature gradient (−20 to + 100C) was maintained. It was found that sensitivity to fast electron tracks can be increased by heating and drying, but that for each emulsion type there is a rather critical temperature above which the growth of random "fog grain" background soon makes the emulsion useless. Attempts to remove the latent image showed that track images are removed more easily than the background, so that the usefulness or emulsions that have been heated too much cannot be regained. An interesting difference was noted in the behavior of pellicles and premounted plates which suggests that the plates are less affected by high temperatures. Measurements of brinell hardness and thermal conductivity as a function of the humidity are reported, as are several comments on the handling of dry emulsions. (auth) (USGRDR)

**16828** (AD-820556) A COMPUTER-AUTOMATED ITERATIVE METHOD FOR NEUTRON FLUX SPECTRA DETERMINATION BY FOIL ACTIVATION. VOLUME I. A STUDY OF THE ITERATIVE METHOD. Technical Report, April 1966–July 1967. McElroy, W. N.; Berg, S.; Crockett, T.; Hawkins, R. G. (Atomics International, Canoga Park, Calif.). Sep 1967. Contracts AF29(601)-7196; AF29(601)-6780. 122p. (AI-67-90(Vol.1); AFWL-TR-67-41(Vol.1)). CFSTI.

A multiple foil activation iterative method has been developed to determine neutron flux spectra. A computer code (SAND II) has been written which provides a best fit neutron differential flux spectrum for a given input set of infinitely dilute foil activities. The results of experimental and analytical studies for a wide variety of neutron environments strongly suggest that, in addition to determining neutron flux spectra, the multiple foil activation iterative method can be helpful in (1) the validation and improvement of calculational techniques used to predict neutron flux spectra, (2) upgrading of confidence in neutron spectrometer measurements, (3) determining the reliability of foil activity measurement methods, (4) assessing materials scattering/absorption effects, and (5) examining current foil detector cross section evaluations to provide guidance for re-evaluation for these data, and eventual "unfolding" of the absolute differential form of cross sections for any foil reactions producing a detectable product. (auth) (USGRDR)

**16829** (AD-821616) A COMPUTER-AUTOMATED ITERATIVE METHOD FOR NEUTRON FLUX SPECTRA DETERMINATION BY FOIL ACTIVATION. Technical Report, April 1966–July 1967. McElroy, W. N.; Berg, S. (Atomics International, Canoga Park, Calif.). Sep 1967. Contracts AF29(601)-7196; AF29(601)-6780. 388p. (AI-67-90(Vol.4); AFWL-TR-67-41(Vol.4)). CFSTI.

The volume documents the current contents of the spectrum library tape; i.e., a reference listing and CRT (Cathode Ray Tube) plots of 59 reference spectra, as well as tabulations of calculated activities for all 29 evaluated reactions for each of the 59 spectra. (auth) (USGRDR)

**16830** (AD-821617) A COMPUTER-AUTOMATED ITERATIVE METHOD FOR NEUTRON FLUX SPECTRA DETERMINATION BY FOIL ACTIVATION. VOLUME II. SAND II (SPECTRUM ANALYSIS BY NEUTRON DETECTORS II) AND ASSOCIATED CODES. Technical Report, April 1966–July 1967. Berg, S.; McElroy, W. N. (Atomics International, Canoga Park, Calif.). Sep 1967. Contracts AF29(601)-7196; AF29(601)-6780. 384p. (AI-67-90(Vol.2); AFWL-TR-67-41(Vol.2)). CFSTI.

A digital computer code is described which determines the form and magnitude of a neutron flux spectrum (over the energy range from $10^{-10}$ to 18 MeV) from multiple foil activation measurements, for both steady-state and pulsed environments. The method is to apply iterative adjustments to an initial input approximation spectrum to yield a solution spectrum which produces calculated activities that agree with the measured activities. Use of the program is also described for performing other useful tasks, such as the initial calculation of activities and energy limits of sensitivity for the selection of an appropriate foil set. One necessary supporting code is described, as are two non-necessary but convenient associated codes. Documentation is provided for Fortran IV source versions of the codes, written for execution on the CDC-6600 computer. (auth) (USGRDR)

**16831** (AERE-R-6220) ASSESSMENT OF PERSONAL FAST NEUTRON DOSES USING AN AUTOMATIC PROTON TRACK COUNTER. Douglas, J. A. (Atomic Energy Research Establishment, Harwell (England)). Dec 1969. 25p. Dep. CFSTI (U. S. Sales Only). UK 4s. 6d.

The present method of visually counting tracks in nuclear emulsion is slow and tedious and results in poor statistics. The use of an automatic counter should eliminate subjective errors and be faster, thus giving greater statistical accuracy. For this reason the basic performance of the Harwell automatic counter for recoil proton tracks, described by Moss, Rae and Wheeler [Nuclear Instr. Meths. 73: 269-274(1969)], and its performance as a fast neutron dosemeter reader have been assessed using nuclear emulsions that have been exposed to mono-energetic protons, neutrons and gamma radiations. It was shown that the minimum length of track recognizable is 5 μm. Other measurements made included track counting efficiency, minimum detectable dose, apparent background dose, effect of track orientation, and the effect of additional gamma dose. The machine performance is better than that obtained with visual counting for neutron badges which have been exposed to neutrons of energy >1.5 MeV but not for low energy neutrons such as those leaking from a reactor. (auth) (UK)

**16832** (CONF-690910–, pp 366-77) RECENT ADVANCES IN FAST-RESPONSE MINIATURE NEUTRON FLUX MONITORS. Stillman, D. B.; Chaney, R. L. ([Los Alamos Scientific Lab., N. Mex.]).

A fast response miniature neutron detector has been developed at the Los Alamos Scientific Laboratory (LASL) to measure temperature-time history of fissile materials under intense neutron irradiation. The fissile-sensing element of the fission couple neutron detector is approximately 0.030 in. in diameter. The detector sensitivity for thermal neutrons is approximately $10^9$ n/cm$^2$–°C. To determine any limitations in response time, fission couples were placed 3 m from a nuclear device in an underground nuclear weapons test at the Nevada Test Site. The detector accurately followed the change in neutron population (alpha measurement) as the device exploded. This rapid change in neutron population had an e-folding time of 20 nsec. A number of experiments were performed in various reactors so that such a detector could be developed. These experiments were conducted in a particular sequence and were aimed at investigating the characteristics, possible uses, and limitations of the fission couple. Some experimental results are discussed. The significance of the results obtained with fission couples suggests numerous applications in neutron diagnostics and reactor controls. The most obvious application for this instrument would be mapping of the neutron flux in and around a reactor. Other possible applications are also discussed. The miniature size and fast response of a fission couple combine to offer unique advantages as a new tool in reactor diagnostics and control. (auth)

**16833** (OU-LNS-69-5) FABRICATIONS AND PROPERTIES OF SILICON DETECTORS. Inoue, Fumie (Osaka Univ. (Japan). Lab. of Nuclear Studies). [1969]. 21p. (In Japanese). Dep. CFSTI (U. S. Sales Only).

Surface barrier detectors, Si(Li) detectors, and Si(Li) surface barrier detectors for nuclear experiments were fabricated. The edges of surface barrier detectors were protected with amine-epoxy. The amine-free epoxy was slightly doped with iodine, and a $\frac{1}{32}$-inch-wide ring of this resin was placed around the edge of the diode. By this treatment, detectors which are stable in a vacuum were obtained. The edges of Si(Li) detectors were covered with polyurethane to protect the detector from normal atmosphere. Characteristics of the Si(Li) detectors were stable in air over a year. Si(Li) surface barrier detectors of 1 to 3 mm effective thickness were fabricated by three methods including the cylindrical type, mesa type, and double-drift type. The method of double-drift type might be the best, especially for detectors of 3 to 5 mm thickness. The properties of these detectors are listed including resistivity, carrier lifetime reverse current, sensitive area, thickness, and resolution. (auth)

**16834** (SZS-8/69) MEASUREMENT OF LOW-ENERGY $\beta$ EMITTERS WITH A SIMPLE LIQUID SCINTILLATION COUNTER. Buschmann, R.; Poulheim, K.-F. (Staatliche Zentrale fuer Strahlenschutz, Berlin (East Germany)). Aug 1969. 28p. (In German). Dep. CFSTI (U. S. Sales Only).

A simple liquid scintillation counter is described which is used for routine measurements of low-energy beta emitters. The apparatus is only suitable for measurements of small sample members. The average efficiency and the minimum detectable activities are given for the nuclides $^{147}Pm$, $^{35}S$, $^{14}C$, and $^{63}Ni$. (auth)

**16835** (SZS-11/69) LARGE VOLUME SCINTILLATION CHAMBER FOR THE MEASUREMENT OF RADON CONCENTRATIONS. Schlueter, W. (Staatliche Zentrale fuer Strahlenschutz, Berlin (East Germany)). Oct 1969. 24p. (In German). Dep. CFSTI (U. S. Sales Only).

A method for measuring the radon content of air is described. The detector is a 2.8 l volume spherical chamber covered internally with ZnS(Ag) and viewed by a 60 mm photomultiplier tube. The counting efficiency for radon in equilibrium with its two $\alpha$-emitting daughters is 20%. The minimum detectable activity (MDA) amounts to $5 \times 10^{-14}$ Ci/l. (auth)

**16836** (UCRL-19363) PRESENT AND PROJECTED USES OF MULTIWIRE SPARK CHAMBERS IN HEALTH PHYSICS. Rindi, Alessandro (California Univ., Berkeley. Lawrence Radiation Lab.). Oct 1969. Contract W-7405-eng-48. 17p. (CONF-691101-15). Dep. CFSTI.

From 2nd International Conference on Accelerator Dosimetry and Experience, Stanford, Calif.

The development and operation of multiwire spark chambers with magnetostrictive readout and also multiwire proportional counters are outlined. Advantages and disadvantages of both of these position-sensitive detectors are pointed out. Also, applications of spark chambers to fields other than high energy physics are discussed including medical use—localizing gamma ray and positron emitters in the body; locating stopped negative pions; and neutron spectroscopy for recording double scattering events of neutrons on protons. (W.H.K.)

**16837** (UCRL-19389) NEW MEASUREMENTS OF STAR PRODUCTION IN NUCLEAR EMULSIONS AND APPLICATIONS TO HIGH-ENERGY NEUTRON SPECTROSCOPY. Patterson, H. Wade; Heckman, Harry H.; Routti, Jorma T. (California Univ., Berkeley. Lawrence Radiation Lab.). 1 Oct 1969. Contract W-7405-eng-48. 18p. (CONF-691101-14). Dep. CFSTI.

From 2nd International Conference on Accelerator Dosimetry and Experience, Stanford, Calif.

When stars are produced in nuclear emulsions by high-energy neutrons there is a strong dependence of the average number of grey prongs per star on the incident neutron energy. This dependence has been measured by exposing emulsion stacks to 27-, 105-, and 230-MeV neutrons produced by deuteron stripping, and to 4-GeV neutrons produced by 6.2-GeV protons incident on a copper target. These results are used to obtain information on the energy distribution of an unknown neutron spectrum from the measurement of the average number of grey prongs per star. We assume a parametric representation of the neutron spectrum, defined by the maximum energy and by the slope of the spectrum on a logarithmic scale, and calculate the average number of grey prongs for a wide range of these parameters. These results are expressed on a single graph which is used to relate the measured average number of grey prongs to a simple exponential spectral shape. The results obtained for a number of accelerator and cosmic-ray spectra are in good agreement with results obtained with threshold detector methods. (auth)

**16838** (UCRL-19392) APPROXIMATE METHODS FOR CALCULATION OF INTRINSIC TOTAL-ABSORPTION- AND DOUBLE-ESCAPE-PEAK EFFICIENCIES FOR Ge(Li) DETECTORS. Euler, B. A.; Kaplan, S. N. (California Univ., Berkeley. Lawrence Radiation Lab.). Oct 1969. Contract W-7405-eng-48. 10p. (CONF-691017-9). Dep. CFSTI.

From 16th Nuclear Science Symposium, San Francisco, Calif.

Approximate methods are presented for calculation of intrinsic total-absorption- and double-escape-peak efficiencies of Ge(Li) detectors. These methods utilize "average" characteristics of gamma-ray photon interactions with matter, and, while developed for specific application to the Ge(Li) detector efficiency problem, should be applicable to any gamma-ray detector or absorptive medium. The technique for total-absorption-peak efficiency determination includes the use of an "average-photon energy-degradation curve" and of the Dirac chord method for calculation of collision probabilities. The average-photon energy-degradation curve is obtained from differential Compton collision cross sections and detector material total-cross-section characteristics; it is independent of detector size and shape. The Dirac chord method is then used to determine the probability of further collisions for photons generated within the detector volume. In the model these probabilities are functions only of a characteristic detector dimension, $\bar{s}\mu$, where $\bar{s}$ is the average chord length and $\mu$ is the total linear attenuation coefficient. Double-escape-peak efficiencies are determined through the calculation of the average probability of occurrence of the following three phenomena: (1) pair production, (2) electron-positron absorption, and (3) annihilation-photon double escape. Complete working curves and expressions are included to enable convenient utilization of these techniques. Example results are compared with efficiency determinations made experimentally and by Monte Carlo calculations. (auth)

**16839** (UCRL-Trans-10427) CALIBRATION OF REFERENCE $\gamma$-RAY SOURCES. Karavaev, F. M.; Yudin, M. F. Translated by T. Watt for Univ. of California Lawrence Radiation Lab., Livermore, from Symposium on Standardization of Radionuclides, International Atomic Energy Agency, Vienna, October 10-14, 1966. 16p. (CONF-661012-13). Dep. CFSTI.

An abstract of this paper, prepared from the original language, appeared as NSA 21: 1624. (W.H.K.)

**16840** (UCRL-Trans-10429) METHODS OF RADIOACTIVITY METROLOGY IN THE USSR. Karavaev, F. M.; Konstantinov, A. A.; Khol'nova, E. A. Translated by T. Watt for Univ. of California Lawrence Radiation Lab., Livermore, from Symposium on Standardization of Radionuclides, International Atomic Energy Agency, Vienna, October 10–14, 1966. 19p. (CONF-661012-12). Dep. CFSTI.

An abstract of this paper, prepared from the original language, appeared as NSA 21: 5823.

**16841** DIVERGING COLLIMATOR FOR GAMMA-RAY IMAGING CAMERAS. Muehllehner, G. (Nuclear-Chicago Corp., Des Plaines, Ill.). J. Nucl. Med.; 10: 197-201(Apr 1969).

The design and performance of a multihole collimator with radially diverging holes of uniform diameter for use with a scintillation camera are presented. The diverging collimator increases the field of view of a scintillation camera at the cost of a 20% loss in resolution and a reduction in efficiency which is proportional to the increase in the field of view. (W.H.K.)

**16842** OPERATIONAL COUNT RATEMETERS AND THEIR APPLICATION TO NUCLEAR MEDICINE. Tanaka, E. (National Inst. of Radiological Sciences, Chiba, Japan). Phys. Med. Biol.; 15: 29-38(Jan 1970).

A theory of the "operational" count ratemeter is described. The ratemeter has two or more CR circuits combined with operational amplifiers and can be used with various frequency responses. The relations between time response, frequency response and the statistical fluctuation of the output are presented. A simple circuit using two CR pairs is proposed, and the formulae for its performance are given. The response can be adjusted to yield critical- or under-damping. A critically damped or a slightly under-damped ratemeter provides a faster response for a sudden change in radiation intensity than conventional ratemeters. For a band-limited input signal, the under-damped ratemeter can enhance the varying component of the signal. Its application to radioisotope imaging is to "enhance" the image, and encouraging results have been obtained in an experiment based on electronic simulation. (auth) (UK)

**16843** SYSTEM FOR RECORDING AND DISPLAYING RADIOISOTOPE SCAN DATA. Dyer, G. R.; McClain, W. J.; Satterfield, M. M. (Oak Ridge National Lab., Tenn.). Int. J. Appl. Radiat. Isotop.; 21: 93-104(Feb 1970).

An integrated-circuit interface for recording radioisotope scan data on magnetic tape via an incremental recorder, and for reading the data from the tape for display on a standard cathode-ray oscilloscope is described. Picture-element counts received from a radioisotope scan are compressed logarithmically to 6 bits/count to be recorded on the magnetic tape. Control pulses originating from the rectilinear scanner store each compressed count on the tape, and generate direction pulses, end-of-line characters, and tape record gaps. Following the recording of one or more scans, or after processing a scan by digital computer, the taped data may be read to provide a fast and flexible two-dimensional map on a laboratory cathode-ray oscilloscope. Data of as many as 60 levels of magnitude are read in continuous mode from the magnetic tape recorder and are displayed immediately on the cathode-ray oscilloscope. A given 6-bit count representing the intensity at the corresponding picture element is converted to an analog signal to provide an unblanking level which controls the number of electrons striking the screen of the scope. Controls are available for providing plan views or isometric views in any desired orientation. (auth) (UK)

**16844** MEASUREMENT OF TRITIUM IN NEAT PLASMA AND URINE WITH A TOLUENE/TRITON X-100/HYAMINE 10-X SCINTILLANT. Whyman, A. E. (General Hospital, Southampton, Eng.). Int. J. Appl. Radiat. Isotop.; 21: 81-6(Feb 1970).

A toluene/Triton X-100/Hyamine 10-X scintillator is described for the colloidal counting of plasma and urine. Counting efficiencies as high as 20% for 1 ml of tritiated plasma or tritiated urine in 10 ml of the toluene/Triton/Hyamine scintillator may be obtained. The new system has been compared with the dioxane based scintillator commonly employed to count plasma water distillates and a considerable improvement in all round efficiency is reported. Finally, it is suggested that the toluene/Triton/Hyamine scintillator is ideal for the measurement of low energy beta emitters in plasma or other body fluids without preliminary preparations. (auth) (UK)

**16845** IMAGE DETECTION METODS FOR 14.5-MeV NEUTRONS: TECHNIQUES AND APPLICATIONS. Berger, H. (CEN, Grenoble, France). Int. J. Appl. Radiat. Isotop.; 21: 59-70(Feb 1970).

Three methods for detecting images with neutrons produced by the T(d,n) reaction are considered. These are (1) the direct method, in which x-ray film with or without intensifying screens is exposed to the neutron beam, (2) the transfer method in which an autoradiograph of a neutron-activated foil is obtained and (3) the track-etch method, in which radiation damage tracks in polycarbonate and cellulose nitrate plastics are made visible. The latter two methods offer the advantage that they are insensitive to gamma rays. Sensitivities and contrast capabilities of each method are discussed. The best methods in each group, with the total fast-neutron exposure needed for a good quality image enclosed in parentheses, are scintillator-film detectors ($5 \times 10^7$ n/cm$^2$) for the direct method, double foil copper screens ($1.2 \times 10^{10}$ n/cm$^2$ for a 30-min, 3 half-life activation) for the transfer method, and a new cellulose nitrate plastic ($2 \times 10^{10}$ n/cm$^2$) for the track-etch method. Applications of these image-detection methods to the study of the uniformity of neutron beams, to the detection of interfering gamma or x-radiation, to the location of irradiation samples in the neutron beam, and to the performance of radiography with fast neutrons are discussed. (auth) (UK)

**16846** THE LUMINESCENCE AND LOW TEMPERATURE SENSITIVITY OF NUCLEAR PHOTOEMULSIONS DOPED WITH CADMIUM. Belous, V. M.; Kartuzhanskii, A. L.; Matvienko, V. I.; Shur, L. I. Opt. Spectrosc. (USSR) (Engl. Transl.); 26: 405-9(May 1969).

Translated from Opt. Spektrosk.; 26: 740-7(May 1969).

The low temperature luminescence of AgBr- and AgBr(I)-photoemulsions of the nuclear type are studied both for samples containing and not containing $CdBr_2$ as an additive. The data obtained are compared with data on their photographic properties. It is shown that in the case of volumetric introduction of $Cd^{2+}$ ions, the point defects produced in the AgHal lattice serve as additional centers for localization of holes and impede their recombination with localized electrons. This effect shows up both in the quenching of luminescence and in an increase in the low-temperature sensitivity of the emulsion. The opposite situation is observed when the $Cd^{2+}$ ions are implanted only on the surface. (auth)

**16847** CONTINUOUS FLOW MEASUREMENT OF BETA RADIATION USING SUSPENDED SCINTILLATORS. McGuinness, Eugene T.; Cullen, Martin C. (Seton Hall Univ., South Orange, N. J.). J. Chem. Educ.; 47: A9-10; A12; A14; A16; A18; A20; A22; A24(Jan 1970).

A brief review of the development of continuous flow detection methods providing nondestructive readout and based on thermal, optical, electrical, or radiochemical properties of monitored effluents for use in liquid column chromatography is presented. The equipment and method for continuous flow measurement of beta radiation over suspended scintillators are described. The selection and modification of the flow cell, calculations for optimum counting conditions, and calculation of system efficiency are discussed. A survey of some nuclides counted including carbon-14, hydrogen-3, phosphorus-32, mercury-203, and chromium-51 is presented. Also, statistics of flow counting is discussed. (34 references) (W.H.K.)

**16848** EVALUATION OF ETCHED SOLID-STATE TRACK DETECTORS BY ALPHA-PARTICLE ABSORPTION MEASUREMENTS. Doerschel, B. (Technische Univ., Dresden). Kernenergie; 12: 303-4(Sept 1969). (In German).

The measurement of the $\alpha$ absorption in mica foils is a new method for the evaluation of solid-state track detectors. The number of $\alpha$ particles, which penetrate the material at the point of etching, is a direct measurement of the track density. The experimental studies made with $^{235}U$ and the results obtained are described. The results show that the $\alpha$ counting rate is a linear function of the track density. (J.S.R.)

**16849** DIP COUNTING OF AQUEOUS SOLUTIONS OF TRITIATED SODIUM DODECYL SULFATE USING A THIN END WINDOW POLY(MONO-CHLORO-P-XYLYLENE) FLOW PROPORTIONAL COUNTER. Rehfeld, Selwyn J. (Shell Development Co., Emeryville, Calif.). J. Colloid Interface Sci.; 31: 46-50(Sep 1969).

Tritium was selected as the $\beta$-emitter in a study of surface adsorption because it is a low-energy $\beta$-emitter (18.5 keV). Thus it has a range of about 0.05 mg/cm$^2$ so that the depth of active solution is ~5000 Å. Therefore, the contribution of the counts originating in the bulk solution to the total counts is much less when using $^3H$ as the $\beta$ emitter (the signal-to-noise ratio is larger for $^3H$). Determination of the adsorption of tritiated sodium dodecyl sulfate (TNaDDS) from aqueous solutions at the poly(monochloro-p-xylylene) interface by dip counting is described. The TNaDDS used in this study has a high chemical and radiochemical purity. The thin end window flow proportional counter used and the tritiation of NaDDS are described. The areas occupied at the surface per adsorbed TNaDDS molecule decrease as the bulk TNaDDS concentration is increased. At and above the critical micells concentration (CMC) the areas per adsorbed molecule computed from radiotracer measurements were essentially constant, in agreement with earlier measurements at solution-air and solution-hydrocarbon interfaces. No experimental evidence was found to confirm the observations of others that an essentially constant area per adsorbed molecule is attained when the bulk surfactant concentration is about half the CMC. (BBB)

**16850** STUDY OF AN APPARATUS FOR REMOVAL OF TWO SCINTIGRAPHIC IMAGES. Desgrez, A.; de Saint-Laurent, J. (CEA, Orsay, France). J. Biol. Med. Nucl.; 4: No. 17, 10-15(May-Jun 1969). (In French).

The automatic removal of two scintigraphic images which permits obtaining pancreatic images much easier to interpret than classical scintigrams is discussed. It removes the interferrence of the hepatic mass. The means of such a removal with the use of a recording device on to a magnetic band directly adaptable to an ordinary sweep scintigraph are studied. The solutions made on two prototypes, developed in two different laboratories and those adapted on commercial versions are compared. Some practical examples are given. (tr-auth)

**16851** LIQUID SCINTILLATION COUNTING MEDIUM FOR AQUEOUS SAMPLES. Kennedy, J. F. (Univ. of Birmingham, Eng.). Experientia; 25: 1120(15 Oct 1969).

Determination of the radioactive content of biological samples which are soluble in water but insoluble in organic solvents presents a problem since scintillation counting is usually carried out in organic solvent systems. Dioxan is a suitable base for a high water capacity liquid scintillator system, and various systems incorporating dioxan were assessed. The one having the best characteristics was prepared by dissolving 2,5-diphenyloxazole (PPO, 40 g), 1,4-bis(2-(5-phenyloxazolyl))benzene (POPOP, 2g) and naphthalene (325 g) in xylene (500 ml), 2-ethoxyethanol (1500 ml) and p-dioxan (1500 ml). This system was capable of accepting water at the rate of 2.2 ml/10 ml scintillator, and the presence of salts in the water did not appreciably alter this figure, e.g., the capacity for 0.5M sodium chloride was 2.1 ml/10 ml scintillator. Counting efficiencies greater than 65% for carbon-14 and 55% for sulphur-35 were obtained for this scintillator system when it contained 2.1 ml 0.5M sodium chloride/10 ml. (W.H.K.)

**16852** LIQUID SCINTILLATION COUNTING. Horrocks, Donald L. (Argonne National Lab., Ill.). Surv. Progr. Chem.; 5: 185-235(1969).

The fluorescence processes which occur in a liquid are briefly described. Practical problems of liquid scintillation counting are discussed, including sample preparation, quenching determination and correction, background, efficiency, and energy response. Emphasis is given to the special problems associated with counting samples containing both hydrogen-3 and carbon-14. Also, some of the newer developments and special applications of liquid scintillators are discussed. (71 references). (W.H.K.)

**16853** SEMICONDUCTOR DETECTORS OF RADIATION AND THEIR APPLICATION TO THE INVESTIGATION OF COSMIC SPACE. Lipinski, A.; Mycielski, W. (Technical Univ., Lodz, Poland). Postepy Astron.; 3: 13-23(1968). (In Polish).

The application of semiconducting detectors to the investigations of cosmic space is discussed. The ways of including detectors with other devices are presented and examples of the use of transistor amplifier sets in collaboration with such detectors are also cited. The effect of radiation on the behavior of semiconducting detectors is discussed, too. (auth) (NSA of Poland)

**16854** SELF-ABSORPTION OF MONOENERGETIC ELECTRONS IN COBALT FOILS. Roach, William H. (Los Alamos Scientific Lab., N. Mex.). Nucl. Sci. Eng.; 39: 258-9(Feb 1970).

The results of measurements to determine the self-absorption of the internal conversion electrons from the 10.5 minute isomeric state of cobalt-60 in their cobalt foils are presented. Measurements were made on cobalt foils in the thickness range from 0.35 to 22 mg/cm$^2$ which were irradiated in a critical assembly whose average neutron energy is above 1 keV. (W.H.K.)

**16855** PARTICLE DISCRIMINATION WITH SOLID-STATE DETECTOR. Abe, Ken (Tohoku Univ., Sendai). Res. Rep. Lab. Nucl. Sci., Tohoku Univ.; 1: No. 1, 20-5(1968). (In Japanese).

Particle discrimination is indispensable in the measurement of nuclear reaction. Various methods which have been developed are discussed. A new method was experimentally examined. This method has the following merits: 1. rapid counting, 2. fine discrimination, 3. broad energy range, 4. easy compensation for the energy dependence of discrimination characteristics, 5. high reliability due to the direct analysis of information, etc. Details of the method, called the "pulse division method," are described, and a schematic diagram is shown. The discrimination of $\alpha$-particles and protons was attempted. Monochromated $\alpha$ and p from $(\gamma,p)$, $(\gamma,\alpha)$ reactions of Be and Co were detected with a Si p-i-n type detector. The output wave forms of the discrimination system for $\alpha$ and proton were shown on an oscilloscope. The possibility of the selective measurement for p and $\alpha$-particle was verified. (NSA of Japan)

**16856** PARTICLE IDENTIFICATION BY PULSE SHAPE DISCRIMINATION. Gatti, E. (CISE, Milan); Cottini, C.; Donati, S.; Svelto, V.; Vaghi, F. Energ. Nucl. (Milan); 17: 34-45(Jan 1970).

The problem of particle identification by means of shape discrimination on the output pulses of a scintillation detector is analyzed both from the theoretical and experimental points of view. First, the problem is examined by a statistical approach to find the optimum filter for pulse shape discrimination and the best attainable result. Second, a discrimination circuit is designed, and its parameter are so adjusted as to match the equivalent illuminations following neutron and $\gamma$-ray excitation of the scintillator. The obtained results prove to be very close to optimum. (auth)

**16857** NEUTRON-INDUCED REACTION STUDIES IN CsI(Tl) BY PULSE SHAPE DISCRIMINATION. Joblin, Arthur. Philadelphia; Drexel Inst. of Tech. (1969). 215p.

Thesis.

Reactions induced in cesium iodide by neutrons in the energy range 13 to 15 MeV have been studied using an improved spectrometer system which employs a two parameter analyzer to identify both particle type and energy. Excellent separation of alpha particles, protons, deuterons, and electrons is achieved. Particles of known energy were used to accurately establish the CsI response function over the entire energy range of interest and for the particles of interest. The experimental response function for protons is found to be non-linear at high energies but this is shown to be due to the strong variation in scintillation decay time with particle energy. An associated alpha particle system is used to measure the neutron flux and to establish absolute cross sections for the neutron induced reactions in CsI. The reaction cross sections are found to be insensitive to the energy of the incident neutron and the average values are $\sigma(n,\alpha) = 0.87 \pm .03$ mb, $\sigma(n,p) = 4.6 \pm 0.2$ mb, and $\sigma(n,d) = 0.83 \pm .03$ mb. The energy spectra for alphas, protons, and deuterons are analyzed in terms of compound nuclear and direct reaction mechanisms using an optical model potential to calculate compound nucleus formation cross sections. Of the total $(n,\alpha)$ and (n,p) cross sections 53% and 43%, respectively, is attributed to the compound nucleus process. The deuteron spectra are well fit by the statistical model but the theoretical cross sections are two orders of magnitude smaller than those observed and it is concluded that the (n,d) reaction proceeds via a direct reaction mechanism. (Diss. Abstr.)

**16858** A VARIATIONAL APPROACH FOR THE DETERMINATION OF NEUTRON FLUX SPECTRA FROM DETECTOR ACTIVATION. Brandon, R. W. (Univ. of Tennessee, Knoxville); Robinson, J. C.; Craven, C. W. Jr. Nucl. Sci. Eng.; 39: 151-62 (Feb 1970).

An expression is derived which relates detector activity to the unperturbed neutron flux and the adjoint difference flux through the use of a variational approach and a transport theory description of the system. The equation is cast in discrete ordinates formalism to permit numerical solution. The self-contained adjoint problem is solved using standard techniques. The unperturbed flux is expanded as a series of Laguerre polynomials, the coefficients of which are determined through inversion of the resulting rectangular matrix. The theoretical model was examined through application to several synthetic problems. A water-moderated spectrum was examined with both perturbed and unperturbed calculations. Direct calculation of perturbed activities showed good agreement with standard activity calculations. Comparable calculations of flux spectra with perturbed and unperturbed activities showed close agreement. The flux spectrum calculations yielded good results in the thermal energy range, and analysis showed that difficulties encountered in the epithermal range were due to the polynomial expansion scheme, as has been previously observed. (auth)

**16859** A VARIATIONAL APPROACH FOR THE DETERMINATION OF NEUTRON FLUX SPECTRA FROM DETECTOR ACTIVATION. Brandon, Robert William. Knoxville, Tenn.; Univ. of Tennessee (1969). 79p.

Thesis.

The problem of determining neutron flux spectra through detector activation is of wide and continued interest in the nuclear industry. Analysis of this problem has historically been divided into two areas of concern. The first area is the evaluation of the perturbation introduced into the flux field by the detector. The second area is the determination of the energy-dependent neutron flux from the integral relationship of neutron flux to detector activity. Through the use of a variational approach and a transport theory description of the system, an expression was derived which relates detector activity to the unperturbed neutron flux and the adjoint difference flux. The equation was cast in $S_n$ formalism to permit numerical solution. The self-contained adjoint problem was solved using standard $S_n$ schemes. The unperturbed flux was expanded as a series of Laguerre polynomials, the coefficients of which were determined through inversion of the resulting rectangular matrix. The theoretical model was examined through application to several synthetic problems. In the first analysis, the inversion scheme was investigated in a problem involving a Maxwell–Boltzmann spectrum in which there was no detector perturbation to the neutron flux. Good agreement was obtained with little dependence on the order of expansion of the unperturbed flux. In the second analysis, a water-moderated spectrum was examined with both perturbed and unperturbed calculations. Direct calculation of perturbed activities showed good agreement with standard activity calculations. Comparable calculations of flux spectra with perturbed and unperturbed activities showed close agreement. The flux spectrum calculations yielded good results in the thermal energy range, and analysis showed that difficulties encountered in the epithermal range were due to the polynomial expansion scheme, as has been previously observed. (Diss. Abstr.)

**16860** SCINTILLATION PULSE SHAPES OF ANTHRACENE SINGLE CRYSTALS IN NANOSECOND REGION. I. INITIAL SPIKES IN $\alpha$-SCINTILLATION PULSE. Owaki, Shigehiro; Kimura, Yoshitake; Kawanishi, Masaharu; Sugihara, Kiyoshi (Osaka Univ.). J. Phys. Soc. Jap.; 28: 691-8(Mar 1970).

The accurate measurement of scintillation pulse shapes of anthracene single crystals has been performed by a newly constructed device with a nanosecond time resolution by means of the sampling method under the pulse height selection and the accumulation of pulse shapes. The distinctive differences between the pulse shapes of luminescence excited by $\alpha$-particles, $\beta$-particles, $\gamma$-rays and UV light pulses were observed. In the case of excitations of $\alpha$-particles, there appeared a characteristic peak which seemed to be superimposed on a scintillation peak excited by $\beta$- or $\gamma$-rays. The dependence of this faster component, that is, the initial spike on the values of dE/dx of $\alpha$-particles in anthracene crystal has been studied. (auth)

**16861** A CHERENKOV COUNTER FOR THE EXTENDED RECORDING TECHNIQUE. Sanin, I. V.; Markov, G. N.; Ivchenko, N. G. At. Energ. (USSR); 27: 354(Oct 1969). (In Russian).

The extended recording method for studying pulsed-neutron sources involves determination of the $\gamma$ radiation due to neutron capture by hydrogen or cadmium. Tests were carried out with this technique using the Cherenkov radiation for recording the Compton electrons generated by the interaction of the capture $\gamma$ radiation with water. The neutrons are slowed down by the water and are captured by hydrogen. The sensitivity of the detector was increased by the dissolution of neutron absorbers possessing a large capture cross section, and an increase of the volume resulted in an increased sensitivity of the instrument. The detector consisted of a 230 × 300 × 380-mm glass container containing 27 l of water with 1.4 kg of dissolved $Cd(NO_3)_2$ or 4 kg of NaCl. (TTT)

**16862** LINE-IMAGE INTENSITY DISTRIBUTION IN THE GAMMA-RAY RADIOGRAPHY AND THE RESPONSE FUNCTION.

Nojiri, Toshiaki; Aonuma, Yoshisuke (Kanagawa Prefectural Industrial Research Inst., Yokohama, Japan). Kanagawa-ken Kogyo Shikenjo Kenkyu Hokoku; No. 25, 59-63(Mar 1969). (In Japanese).

The line-image intensity distribution for a combination of an industrial x-ray film and a sensitizing lead-foil, with a slit was measured for the three sources $^{60}Co$, $^{137}Cs$ and $^{192}Ir$. A few problems in this measurement, such as the effect of geometric conditions, error in the measurement, and the correction for the slit width, are discussed; and the dependency of the response function on gamma-ray energy is shown. The unsharpness defined and proposed by Halmshaw was also obtained from the intensity distribution function of edge images. In view of the analysis of x-ray images made generally by introducing the response function, an experiment was performed to find values of the response function obtainable in gamma-ray radiography. While the error was expected to be high in the slit-image measurements, the necessary measuring accuracy was determined. The reciprocal of the values at the center, when the areas under the curves of the line-image intensity distribution function were made into one, gives the essential unsharpness of Halmshaw. (NSA of Japan)

**16863** A QUENCHING CIRCUIT OF VERY SHORT RISE TIME FOR GEIGER–MUELLER COUNTERS. Eckey, H. (Univ. Muenster, Ger.). J. Phys., E (London); 3: 251(Mar 1970).

In reply to the letter by Kemplay (J. Phys. E., 3: 251 (March 1970)) the advantages of a short rise time of a quenching pulse in the performance of a quenching unit are described. It is stated that the reliability of the circuit has been proved under laboratory conditions for which it was designed. (UK)

**16864** IMPROVEMENTS IN OR RELATING TO PROPORTIONAL COUNTERS. Salmon, Percy George; Hall, John William; Wraight, Leonard Arthur (to United Kingdom Atomic Energy Agency). British Patent 1,179,406. 28 Jan 1970. Filed 28 Feb 1966.

Proportional counters have not hitherto provided an indication of the position of impact of an incident charged particle. The counter described comprises an elongated enclosure containing a gas and two elongated electrodes laterally spaced, one of these electrodes being electrically resistive; means are provided for applying a potential across the electrodes and for determining the proportions of the charge, resulting from an ionizing event within the enclosure, which flow to the ends of the resistive electrode and are collected on this electrode. The relative proportions of charge collected provide an indication of the position along the length of the counter at which the ionizing event occurred. Several alternative means are described for determining the relative proportions of charge by production of suitable signals with indicating means. One electrode may comprise a hollow cylinder and the other a wire extending along the axis of the cylinder. (UK)

**16865** A DEVICE FOR COUNTING PULSES. Barenboim, Arkady Moiseevich (to Moskovsky Zavod Elektrovakuumnykh Pribororov). British Patent 1,178,576. 21 Jan 1970. Priority date 15 Apr 1966, Russia.

A device for counting pulses in which a gas discharge tube is arranged to be controlled by two trains of pulses in antiphase which are applied via input circuits to cathodes of the gas discharge tube is described. The cathodes are electrically interconnected into two groups with adjacent cathodes in different groups. (C.E.S.)

**16866** IMPROVEMENTS IN OR RELATING TO GEIGER–MUELLER COUNTERS. Salmon, Percy George (to United Kingdom Atomic Energy Agency). British Patent 1,179,407. 28 Jan 1970. Filed 28 Feb 1966.

Geiger counters can readily be made of length, say, a meter, but hitherto it has not been possible to determine the position along their length at which an ionizing event occurs. The counter described comprises a gas filled enclosure, with an elongated cylindrical cathode mounted within or forming an inner lining of the enclosure and a wire anode mounted within the cathode. Means are provided for applying suitable operating potentials to the cathode and anode, and to prevent the discharge resulting from an ionizing event spreading along the anode. Means are also provided to determine the position on the anode at which the charge due to an ionizing event within the counter is collected. The means to prevent the discharge spreading along the anode preferably comprises a series of equally spaced glass-beads mounted on the anode. Several alternative means are described for determining the relative proportions of charge flowing to the ends of the anode by production of suitable signals with indicating means. Two forms of GM counter employing this principle are described. (UK)

**16867** A CONTRAST EFFICIENCY FUNCTION FOR QUANTITATIVELY MEASURING THE SPATIAL-RESOLUTION CHARACTERISTICS OF SCANNING SYSTEMS. Rollo, F. D.; Schulz, A. G. (Johns Hopkins Medical Institutions, Baltimore. Johns Hopkins Univ., Silver Spring, Md.). J. Nucl. Med.; 11: 53-60 (Feb 1970).

A new function is proposed to fulfill a standing need for a quantitative method for characterizing the resolution of a scanning system. It is postulated that any characterization of the resolution of a system must be referred to an input problem or related class of problems. To provide a definition for the input problem, the concept of the spectrum of a lesion or organ is proposed and defined on the basis of the transform of the representation of a scan made with an ideal system. The contrast efficiency function is then defined as the ratio of the contrast obtained in a scan of a lesion with a system of interest to that obtained with such an ideal system. Mathematically, the function is a measure of how well the transfer function of the system matches the spectral density of the scanning problem. The $E_c$ concept has special advantage since it permits comparison of resolution performance between systems as well as within a single system where parameters affecting resolution characteristics are varied. (auth)

**16868** QUANTITATIVE ASSESSMENT OF SCANNING-SYSTEM PARAMETERS. Schulz, A. G.; Knowles, L. G.; Kohlenstein, L. C.; Mucci, R. F.; Yates, W. A. (Johns Hopkins Univ., Silver Spring, Md.). J. Nucl. Med.; 11: 61-8(Feb 1970).

A system has been developed with which quantitative evaluation of scanning-system effectiveness in terms of the lesion detection and location performance of observers is practical. The process of scanning a three-dimensional nuclide distribution with a radionuclide imaging system has been digitally simulated. With this simulation it is possible to vary in a flexible manner the parameters associated with the radiopharmaceutical, the organ and abnormalities, the collimator-detector, the data processing and the display. A simulated scan including the statistical fluctuations can be produced and displayed on a cathode-ray viewing screen or recorded on magnetic tape at a rate of 3/min. This speed permits quantitative conclusions about the effects of variations in the scanning system on a basis of a statistically significant number of scans. Scans of a kidney containing $^{197}Hg$ were simulated. The parameters varied were the count density in the image and the size of the spherical lesions. Changes in count density were related to corresponding changes in the activity within the organ, in the scan time and in the crystal size. The frequency with which the observer detected the abnormalities under the various conditions is reported for several levels of observer confidence. The curves provide a measure of the value of increased count density and of the relative detectability of different-size lesions in a shallow organ such as the kidney. (auth)

**16869** IMPROVEMENTS IN SYSTEMS FOR DISCRIMINATING RADIATIONS OF DIFFERENT NATURE. (to Compagnie Francaise Thomson Houston-Hotchkiss Brandt). British Patent 1,181,984. 18 Feb 1970. Priority date 1 Jul 1966, France.

A system for discriminating between simultaneously detected $\alpha$ and $\beta$ radiations comprising a double-purpose scintillator having a component sensitive to $\alpha$ radiation and a component sensitive to $\beta$ radiation is described. (C.E.S.)

**16870** SEMICONDUCTOR RADIATION DETECTION APPARATUS. (to Philips Electronic and Associated Industries Ltd.). British Patent 1,178,199. 21 Jan 1970. Priority date 25 Oct 1967, Netherlands.

A semiconductor detector with an electrode divided into a number of parallel electrode strips that are separate from each other, which can be used for determining the position at which the radiation is incident, is described. (C.E.S.)

**16871** MEASUREMENT OF THE SCATTERED RADIATION COMPONENT IN RADIOGRAPHY. Stieve, F. E.; Schaal, A.; Widenmann, L. (Univ., Munich. Siemens AG, Erlangen, Ger.). Fortschr. Geb. Roentgenstr. Nuklearmed; 107: 521-8(Oct 1967). (In German).

After the discussion of the various ways of measuring scattered radiation, an account is given of the ionization method which was used. The method makes it also possible to measure the scatter dose which emerges from the patient under radiographic conditions. The scatter dose transmitted by a grid can also be measured. The method which is based on ionization has the disadvantage of requiring a detector size which is larger than the film or the luminescent material used for dosimetry. On the other hand the method permits the direct determination of absolute values. It also has assets in the application to practical work. The method is sufficiently accurate under routine conditions. (auth)

## *Nuclear Spectroscopic Instrumentation*

*Refer also to abstract 18367.*

**16872** (AD-695646) ANALYSIS OF UNFOLDING GAMMA-RAY SPECTRA MEASURED BY COMPTON-DIODE DETECTORS. Wortman, Donald E.; Morrison, Clyde A.; Karayianis, Nick (Harry Diamond Labs., Washington, D. C.). Jul 1969. 33p. (HDL-TR-1454). CFSTI.

Several of the methods that might be used in constructing a gamma-ray spectrum as measured by a finite number of detectors are compared. Particular emphasis is placed on determining how well an incident spectrum can be represented by measurements taken with five Compton-diode detectors arranged in tandem. Several numerical examples are given illustrating that many methods devised to approximate the incident spectrum can yield erroneous results. These numerical calculations indicate the advantages of a method presented earlier over other methods in determining an unknown gamma-ray spectrum. These examples substantiate this earlier work in showing that probably the best representation of the unknown spectrum can be obtained by expanding the spectrum in terms of the response functions of the system. Any component of the incident spectrum that is orthogonal to all the response functions will not contribute to the output; hence such a component of the spectrum would not be detected by the measuring device. In this sense, the solution contains all the information about the unknown spectrum that the measurements are capable of giving. An analytic form for the response functions of the Compton diodes which were previously determined by Monte Carlo calculations at discrete energy points is also given. (auth) (USGRDR)

**16873** (ORNL-TM-2865) A VARIABLE-GRID RESPONSE MATRIX FOR A 5 x 4 NaI SCINTILLATION SPECTROMETER. Pleasonton, Frances; Lide, R. W. (Oak Ridge National Lab., Tenn.). 5 Feb 1970. 17p. Dep. CFSTI.

A 16 × 16 triangular response matrix was developed for analysis of the continuous pulse-height distribution observed from prompt gamma rays emitted in fission. It combines information from measured pulse-height distributions, obtained with calibrated gamma ray sources, with Monte-Carlo calculations of distributions to be expected from monoenergetic sources detected in the geometry of the experiment. (These calculations were carried out using the program MORN, of Zerby and Moran, as revised by Rodda.) (auth)

**16874** AIRBORNE GAMMA-RAY SPECTROMETRY. Darnley, A. G. (Geological Survey of Canada, Ottawa). CIM (Can. Mining Met.) Bull.; 63: 145-54(Feb 1970).

The Geological Survey of Canada is devoting considerable effort to finding ways to make airborne radiometric measurements both quantitative and reproducible. Equipment has been designed by Atomic Energy of Canada Ltd. to provide high count rates in order to minimize statistical uncertainty, this being essential to justify applying terrain clearance and Compton scattering corrections to the data. Correction factors were determined experimentally and can be applied automatically. Considerable ground work was undertaken in parallel with equipment development in order to determine field parameters. Two airborne gamma-ray spectrometers are described. One is based on three 5- by 5-inch NaI(Tl) detector crystals and is used in a helicopter; the other employs twelve 9- by 9-inch detectors and is used from a Skyvan aircraft. The former is being used to investigate the range of radiometric response from specific rock types, and for the correlation of ground and air measurements; the latter has completed initial trials and will be commencing experimental surveys during 1969. Results are given to show the comparative sensitivities of the various detector sizes, and operational requirements for a gamma-ray spectrometer survey are discussed briefly. (auth) (Canada)

**16875** SYSTEMATIC ANALYSIS OF THE PERFORMANCE OF SPECTRUM STABILIZERS BY MEANS OF LINEAR APPROXIMATION OF TRANSFER FUNCTIONS. Yamashita, Mikio; Michikawa, Taichi (Electrotechnical Lab., Tokyo). J. Nucl. Sci. Technol. (Tokyo); 6: 678-88(Dec 1969).

A systematic approach has been made to theoretical estimation of the basic parameters characterizing the different types of spectrum stabilizers and also of their control performance. The transient responses to regular disturbances, and the mean square errors due to random disturbance and statistical fluctuations in the counting rates have been treated analytically with use made of linear approximation of the transfer functions. The results obtained are valid only in the limit of small gain shifts in comparison with the half width of the reference peak, but nevertheless they still provide a measure for predicting the requirements for optimum control as well as an indication of the limitations to their range of applicability. (auth)

**16876** PULSE-SHAPE DISCRIMINATION TECHNIQUES FOR NEUTRON SPECTROSCOPY. Kinbara, Setsuo (Japan Atomic Energy Research Inst., Tokai, Japan). Genshiryoku Kogyo; 15: No. 12, 57-63(Dec 1969). (In Japanese).

First, the typical neutron detectors such as $BF_3$, fission, $^3He$, proton recoil, organic and inorganic scintillation, and Si surface barrier types are described. In measuring the neutron energy spectrum by detectors, it is necessary to make pulse-shape discrimination, especially in the low-energy region, in order to lower the $\gamma$-ray background. In this connection, the method of pulse-shape discrimination is explained including the use of a photomultiplier tube; rise-time discrimination; amplitude discrimination; comparison of the delay components; and the direct measurement. Finally, the two types of systems for pulse-shape discrimination developed in JAERI are described. They are Model 154A Risetime To Height Converter (RHC), and Model 155 Shape To Height Converter (SHC). Concerning the amplitude characteristics, the accuracy is below ±1% in the amplitude range of about 20 : 1. The linearity in rise-time and in pulse-width are fairly good, though it depends on the pulse-shape and other conditions. These are applicable for n-$\gamma$ discrimination with a scintillation counter, proportional counter and semiconductor detector, and for other purposes. (NSA of Japan)

**16877** EFFICIENCY AND PRECISION OBTAINED IN COMPENSATION OF THE TERRESTRIAL MAGNETIC FIELD WITH DIFFERENT SYSTEMS OF WINDINGS IN DEVELOPMENT OF A $\beta$ SPECTROMETER. Mugnier, Daniel; Dauphine, Francis; Chery, Roland; Lafoucriere, Joseph (Univ., Lyon). Compt. Rend., Ser. B; 269: 925-8(3 Nov 1969). (In French).

The development of a beta spectrometer with trochoidal trajectories by means of windings without iron involves compensation of the terrestrial magnetic field which is at the same time the most precise and effective possible. The latter quality is made indispensible by the very large spatial extension of the charged particle trajectories in an apparatus of this type. The proposed methods lead, for this problem and for precision of the order of $10^{-4}$, to the selection of a combination of six or eight pairs of circular windings. (tr-auth)

## *High Energy Physics Instrumentation*

*Refer also to abstract 18096.*

**16878** (BMBW-FBK-69-45) CYLINDRICAL SPARK CHAMBER SYSTEM WITH MAGNETOSTRICTIVE READOUT. Beckermann, M.; Heintze, J.; Siebert, H. W.; Stelzer, H. (Heidelberg Univ. (West Germany). Physikalisches Institut (I)). Dec 1969. 5p. (In German). Dep. CFSTI (U. S. Sales Only). ZAED.

A system of concentric cylindrical spark chambers with magnetostrictive readout is described. Each chamber consists of two self-supporting electrode cylinders made out of printed circuit foil with wire strips spiralling along the cylinders in opposite directions. This allows accurate two-dimensional readout of rectangular coordinates through readout wires strung around one edge of the cylinders. Therefore the chambers contain no dead zones or support materials in the sensitive part of the cylinder. The precision of spark location, as gained from an experiment at CERN, was 1.6 mm FWHM in the longitudinal and 1.3 mm FWHM in the azimuthal direction. (auth)

**16879** (CERN-69-29, pp 123-60) NEW DEVELOPMENTS IN ELECTRONIC POSITION DETECTORS. Morgan, C. Grey (University Coll. of Swansea (Wales). Dept. of Physics).

High-energy beams and some methods and systems of electronic position detectors which are being developed are discussed. Spark and streamer chambers, and electronic methods for examining bubble chamber film records are covered. This discussion includes secondary electron emission monitors, the semigrid profile monitor, secondary-electron emission probe beam scanner, synchrotron radiation, and position detectors based on residual gas ionization. Also included are phosphor screen and strip-electrode detection systems, the CERN PS ionization beam scanner, an inductive beam position monitor, track detection using electrical discharges in gases, electronic bubble chamber record analysis, and the possibility of using laser radiation to detect particles. (J.F.P.)

**16880** (CERN-69-29, pp 161-80) EVOLUTION OF SOME PARTICLE DETECTORS BASED ON THE DISCHARGE IN GASES. Charpak, G. (European Organization for Nuclear Research, Geneva (Switzerland)).

The properties of some detectors commonly used in counter experiments to localize charged particles, and which are based on discharge in gases under the influence of electric fields, are summarized. Some basic facts of gaseous amplification in homogeneous and inhomogeneous fields are reviewed. The treatment covers field distribution around wire electrodes, the effect of electric fields on free electrons in a gas-memory of chambers, gaseous amplification in the uniform region, automatic spark chambers, and the multiwire proportional chambers. (J.F.P.)

16881 (CERN-69-29, pp 181-206) OMEGA PROJECT. Michelini, A. (European Organization for Nuclear Research, Geneva (Switzerland)).

The Omega project consists of a large spectrometer magnet, a system of detectors, such as spark chambers and counters, operating inside the field volume, and a data acquisition system which is based on two on-line computers. The useful magnetic field of 18 kG extends over a volume of 3 m diameter by 2 m height. The design and operation of this detector system are discussed, and possible experiments using the Omega project are mentioned. (J.F.P.)

16882 (CONF-690330-, pp 61-71) DETECTION NEAR A MULTI-GeV RING. Nguyen Ngoc, H. (Paris Univ., Orsay (France). Laboratoire de l'Accelerateur Lineaire). (In French).

The properties of a detector for use near a multi-GeV ring are described. The separation of charged particles, the solid angle, and logic including cost and reliability are discussed. (J.F.P.)

16883 (IS-2231) PHYSICS USE OF THE AMES LABORATORY ON-LINE MEASURING SYSTEM FOR BUBBLE CHAMBER EVENTS. Schalk, T. L.; Kernan, W. J. (Ames Lab., Iowa). Dec 1969. Contract W-7405-eng-82. 14p. Dep. CFSTI.

The use of the Ames Laboratory on-line measuring system for bubble chamber events is described using the measurement of "Vee" events in $\bar{p}p$ experiments at 2.4 and 2.9 GeV/c as an illustration. Simplified flow charts of the control routines and systems are presented. The physics basis of the design is shown and discussed. (auth)

16884 (ITEF-689) ITEP 2-METER LIQUID HYDROGEN BUBBLE CHAMBER. Aleshin, Yu. D.; Arutyunyantz, G. A.; Verebryusov, V. S.; (and others) (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Moscow. Institut Teoreticheskoi i Eksperimental'noi Fiziki). 1969. 24p. (In Russian). Dep. CFSTI (U. S. Sales Only).

The design and operation characteristics of the 205 × 60 × 41 cm liquid hydrogen bubble chamber are given. The expansion system consists of a 30-cm-diameter piston and two three-step pneumatic valves. The thermostabilization system keeps the temperature constant within the chamber volume up to 0.1°K. The illumination is performed with three flash tubes or lasers and a retrodirective "coathanger" system. Three f = 200 mm lenses and unperforated 80 mm film are used. The magnetic field equals 21.7 kilogauss at 3.8 MW. The chamber can be exposed to the beams of 3 to 5.2 GeV/c secondary particles from the ITEP proton synchrotron. Tracks were obtained at 28.6°K, 6.3 absolute atmospheres and 2.2 atm pressure drop. (auth)

16885 (PPAD-671-E) OPERATING EXPERIENCE WITH A MODULAR DIGITAL DATA SYSTEM FOR HIGH ENERGY PHYSICS. Droege, T.; McFadden, J.; Wash, S.; VonColln, R. (Princeton-Pennsylvania Accelerator, Princeton, N. J.). 17 Nov 1969. Contract AT(30-1)-2137. 22p. (CONF-691017-7). Dep. CFSTI.

From 16th Nuclear Science Symposium, San Francisco, Calif.

A modular digital data system originally designed for magnetostrictive wire spark chambers has been expanded to include most digital high energy physics data. The system is built around a 12 bit data bus and has been implemented for a number of computers and other output devices. Three years of operating experience are summarized. (auth)

16886 (UCRL-19383) SOME THOUGHTS ON THE DATA ACQUISITION PROBLEM OF HIGH-ENERGY PHYSICS EXPERIMENTS. Kirsten, Frederick A. (California Univ., Berkeley. Lawrence Radiation Lab.). Nov 1969. Contract W-7405-eng-48. 11p. (CONF-691017-8). Dep. CFSTI.

From 16th Nuclear Science Symposium, San Francisco, Calif.

Some of the questions that arise when considering a standard data-bussing system are discussed. The discussion is restricted to applications in high-energy physics instrumentation. It is pointed out that it is necessary to provide for the operation of such systems without on-line computers. (auth)

16887 STEREO READING APPARATUS WITH REDUNDANCY. Clark, A. F.; Hansen, N. E.; Smith, D. E. (Univ. of California, Livermore). Rev. Sci. Instrum.; 41: 408-10(Mar 1970).

A stereo apparatus for cloud chamber pictures has been developed which uses four cameras to give six possible stereo pairs. Comparison among the various views permits positive identification and measurement of every track in the chamber, even with a large number of tracks. (auth)

16888 THE DESIGN AND PERFORMANCE OF A GAS CHERENKOV COUNTER WITH LARGE PHASE-SPACE ACCEPTANCE. Hinterberger, H.; Lavoie, L.; Nelson, B.; Sumner, R. L.; Watson, J. M.; Winston, R.; Wolfe, D. M. (Univ. of Chicago). Rev. Sci. Instrum.; 41: 413-18(Mar 1970).

The design and performance of a threshold gas Cherenkov counter used to detect electrons from lambda beta decay are described. To achieve the very large phase-space acceptance required, the counter incorporates a novel technique of light collection, the light funnel which we developed for this purpose. By means of the light funnel one can, in principle, make the entire phase-space acceptance of a photomultiplier tube useful for particle detection. (auth)

16889 BUBBLE-CHAMBER PICTURE PROCESSING THROUGH DIGITAL FILTERING. Gazdag, Jeno (IBM Scientific Center, Palo Alto, Calif.). J. Comput. Phys.; 5: 34-55(Feb 1970).

A method is presented for the decomposition of bubble-chamber pictures. Two illustrative examples are discussed. One is the suppression of beam tracks. The other deals with the isolation of event tracks from a noisy background. The scheme makes effective use of finite Fourier transform methods. (auth)

## Radiation Dosimeters

*Refer also to abstracts 16831, 17160, 18699, and 18705.*

16890 (AHSB(RP)R-95) RADIOTHERMOLUMINESCENT DOSIMETRY. Report of a Panel of the UKAEA Health Physics Co-ordinating Committee. Saxby, W. N.; White, D. F. (eds.) (United Kingdom Atomic Energy Authority, Harwell (England). Authority Health and Safety Branch). Jan 1970. 20p. Dep. CFSTI (U. S. Sales Only). UK 3s. 6d.

The Health Physics Coordinating Committee of the UKAEA set up a panel on radiothermoluminescent dosimetry in 1966. An edited version of the report and recommendations made by the panel to the HPCC in December, 1968, as amended by the latter Committee is presented. It deals with current work and progress in the United Kingdom in the field of radiothermoluminescent dosimetry (TLD), with the capabilities and applications of TLD, with current and future research and development work and with the rationalization of equipment and procedures. The Panel membership represented almost all those UK bodies actively involved in TLD work in radiological protection, and constituted a useful discussion group for the exchange of information in this field. (auth)

16891 (ANL-Trans-809) PROGRAMMED HEATING DEVICE FOR THE MEASUREMENT OF THERMOLUMINESCENCE. Mezhs, T. K. Translated for Argonne National Lab., Ill., from Latv. PSR Zinat. Akad. Vestis, Fiz. Teh. Zinat. Ser.; No. 6, 49-53(1967). 8p. Dep. CFSTI.

A programmed heating system which provides variable heating rates for thermoluminescence studies is described. (W.H.K.)

16892 (JINR-P13-4848) RECORDING CHARGED PARTICLE TRACKS IN THE ALKALI-HALIDE CRYSTALS. Golovin, B. M.; Nikanorov, V. I.; Pisarev, A. F. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1969. 10p. (In Russian). Dep. CFSTI (U. S. Sales Only).

For the detection of charged particles in the alkali-halide crystals it is suggested to excite and then to detect the luminescence of F-centers, produced by particles along their tracks. (auth)

16893 CHEMICAL DOSIMETER SYSTEM FOR MIXED NEUTRON AND GAMMA RADIATION. Ahnstroem, G. (Stockholm Univ.) pp 107-9 of Neutron Irradiation of Seeds. Pt. II. Vienna; International Atomic Energy Agency (1968).

From FAO/IAEA Meeting on Co-ordination of Research on the Use of Neutrons in Seed Irradiation, Vienna, Austria. See STI/DOC-10/92; CONF-671221.

G-values for the Fricke dosimeter and the FeCu dosimeter were calculated for moderated fission neutrons. By combining these two chemical dosimeters, the fast neutron and gamma doses can be measured separately in a mixed field. (auth)

16894 CONSTRUCTION OF IONIZATION CHAMBERS FOR FAST NEUTRON AND GAMMA DOSIMETRY IN THE NEUTRON SEED IRRADIATION PROGRAM. Ahnstroem, G. (Stockholm Univ.). pp 111-12 of Neutron Irradiation of Seeds. Pt. II. Vienna; International Atomic Energy Agency (1968).

From FAO/IAEA Meeting on Co-ordination of Research on the Use of Neutrons in Seed Irradiation, Vienna, Austria. See STI/DOC-10/92; CONF-671221.

A pair of ionization chambers were constructed for the measurement of fast neutron and gamma dose-rates. One chamber has a wall material of magnesium and a chamber gas of argon for measuring the gamma dose-rate. In the other chamber both the wall and the gas have the atomic composition CH. This chamber registers the sum of the fast neutron and gamma dose-rates.

Details of constructing and calibrating such chambers are given. (auth)

**16895** COMPARISON BETWEEN SPECTROMETRY IONISATION CHAMBER, AND THRESHOLD DETECTOR SYSTEMS FOR FAST-NEUTRON DOSIMETRY IN THE SUBCORE FACILITY OF A SWIMMING-POOL REACTOR. Chadwick, K. H.; Oosterheert, W. F.; Puite, K. J. (TAL, Wageningen, The Netherland). pp 123-30 of Neutron Irradiation of Seeds. Pt. II. Vienna; International Atomic Energy Agency (1968).

From FAO/IAEA Meeting on Co-ordination of Research on the Use of Neutrons in Seed Irradiation, Vienna, Austria. See STI/DOC-10/92; CONF-671221.

Dosimetry and spectral measurements were made in a fast-neutron facility using systems recommended in the IAEA Technical Reports Series No. 76. The spectrometry system gives the spectrum shape and the kerma rate calculated from the spectrum agrees with the dose-rate measured with ionization chambers. The threshold detectors give a reasonable indication of the spectral shape, but should not be used as a basis for dose calculations. (auth)

**16896** DETERMINATION OF FAST-NEUTRON FLUX DENSITIES AND DOSE-RATES BY THRESHOLD DETECTORS. Koehler, W. (International Atomic Energy Agency, Vienna). pp 137-42 of Neutron Irradiation of Seeds. Pt. II. Vienna; International Atomic Energy Agency (1968).

From FAO/IAEA Meeting on Co-ordination of Research on the Use of Neutrons in Seed Irradiation, Vienna, Austria. See STI/DOC-10/92; CONF-671221.

The neutron flux densities between 0.1 and 10 MeV were determined by a three-group method using four threshold detectors in irradiation facilities of a light-water moderated reactor. With the values obtained the dose-rates for CH-material were calculated. The technique described can be used in a SNIF, and will provide sufficient information for most of the seed irradiated experiments. (auth)

**16897** EFFECT OF THERMAL NEUTRON IRRADIATION ON THERMOLUMINESCENT RESPONSE OF CON-RAD TYPE-7 LITHIUM FLUORIDE. Mason, E. W. (Radiological Protection Service, Glasgow). Phys. Med. Biol.; 15: 79-90(Jan 1970).

The nature of the changes in TL response of CON-RAD Type-7 lithium fluoride, after irradiation in a mixed field of thermal neutrons and $\gamma$-rays, has been examined, and in particular, the modifications observed in the glow pattern after irradiation of the phosphor at a reactor thermal column. It has been shown that for values of the ratio of the thermal neutron fluence rate to the $\gamma$-ray dose rate which are typically found at a reactor thermal column, the response of the phosphor to thermal neutrons is significant. An attempt has been made to explain how the observed modifications in TL behavior arise. Recommendations are made regarding the use of Type-7 LiF for the determination of the $\gamma$-ray component of mixed thermal neutron/$\gamma$-ray fields. (auth) (UK)

**16898** PLASTIC IRRADIATION VESSELS FOR FERROUS SULPHATE DOSIMETRY. Law, J. (Royal Infirmary, Edinburgh). Phys. Med. Biol.; 15: 117-20(Jan 1970).

The possible chemical contamination arising from the use of plastic irradiation vessels for ferrous sulfate dosimetry was measured using several different specimens of polyethylene and one of Perspex. Little effect on ferric ion yield was seen in the results. (UK)

**16899** ADIABATIC CALORIMETRY OF REACTOR RADIATIONS. Briskman, B. A.; Matveev, Yu. V.; Vasil'ev, A. G. At. Energ. (USSR); 27: 342-3(Oct 1969). (In Russian).

Descriptions are given of the design and performance of an adiabatic calorimeter for reactor radiation dosimetry, constructed with polyethylene, polystyrene and graphite, with an external diameter of 50 mm and a wall thickness of 3 mm. The efficiency of the working materials and the relative contribution of neutron component for various reactor channels are tabulated. (R.V.J.)

**16900** ENERGY DEPENDENCE OF A LITHIUM FLUORIDE THERMOLUMINESCENCE DOSIMETER. Gubatova, D. Ya. (Inst. of Physics, Riga). Latv. PSR Zinat. Akad. Vestis, Fiz. Teh. Zinat. Ser.; No. 5, 9-16(1969). (In Russian).

Interaction coefficients for electromagnetic radiation with LiF and the energy dependence of a lithium fluoride TLD have been calculated. The energy dependence for the dosimeter has been determined experimentally. The dosimeter can be applied to determining the exposure doses of electromagnetic radiation with the energies from 10 keV to 1 MeV and higher with an accuracy up to ±36% caused by the energy dependence. Also, it can be used for determining absorbed radiation doses in muscular and bone tissues with an accuracy of ±40% at 10 keV and higher. Results of calculations on the compensative filters which diminish the energy dependence to ±5% are presented. (auth)

**16901** RADIATION DOSIMETER. Oberhofer, Martin; Jaspert, Jurgen (to European Atomic Energy Community). British Patent 1,180,246. 4 Feb 1970. Priority date 21 Dec 1966, Netherlands.

A thermoluminescent dosimeter for registering epithermal and fast neutrons is described. The sensitive material consists of a mixture of lithium hydride and lithium fluoride. (C.E.S.)

**16902** LEAKAGE CURRENT MEASURES DOSE RATE. Wolschendorf, K. (Institut fuer Angewandte Physik, Kiel). Atomkernenergie; 15: 81-2(1970).

Commercially available low-voltage electrolytic capacitors with capacitances between 10$\mu$F and 70$\mu$F and leakage currents of less than $10^{-9}$ A were subjected to x rays of 5 kV peak voltage. The increase of the leakage current of the capacitors upon irradiation was investigated and the leakage current was found to be linearly dependent upon dose rate. (C.E.S.)

**16903** IMPROVEMENT RELATING TO SIMULATORS FOR NUCLEAR RADIATION DOSIMETERS. Spencer, R. E. (to Electric and Musical Industries, Ltd.). British Patent 1,177,936. 14 Jan 1970. Filed 17 Mar 1966.

The object of the apparatus described is to provide means for indicating the total dose experienced by personnel under training in a simulated radiation field. The nuclear radiation field is simulated by an rf electromagnetic radiation field, and means are provided for renewing the strength of this field and setting up a current proportional to the field strength which is applied to an electrolytic cell that includes means for indicating the deposition of material on an electrode, this giving a measure of total radiation dose. The sending means may include an aerial system, together with amplifier and rectifier. The electrolytic cell may comprise a sealed tube of translucent material that encloses two columns of Hg perforated by a small gap filled with a solution which includes a Hg salt; electrodes are provided for the Hg columns, and the indicating means comprises movement of the gap along a scale, giving a measure of material deposited on the electrode. (UK)

## Radiometric Instruments

*Refer also to abstracts 16688 and 16690.*

**16904** (AD-696586) DESIGN AND DEVELOPMENT OF AN ISOTOPIC ALTIMETER SETTING INDICATOR. VOLUME II. APPENDIXES. Final Report. Sellers, B.; Morel, P. (Panametrics, Inc., Waltham, Mass.). Jun 1969. Contract FA-67-WA-1659. 89p. (FAA-RD-69-38-2). CFSTI.

Design and development of an altimeter setting indicator system based on use of a radioactive alpha particle emitter as the primary sensing mechanism is described. Because the isotope measures density, a controlled temperature enclosure is utilized to provide an output proportional to pressure. The system uses a computer controlled closed loop servo to maintain the source at the "constant range" position with respect to the detector. A shaft encoder maintains continuous knowledge of the actual source-detector distance, by which the pressure is deduced from a calibration curve. The altimeter setting indicator is calculated by the computer and displayed digitally. In its present form the system does not meet the design objective accuracy of plus or minus 0.005 inches of mercury. It is believed, however, that when temperature instabilities are corrected this objective will be achieved. (auth) (USGRDR)

**16905** (AD-696961) DESIGN AND DEVELOPMENT OF AN ISOTOPIC ALTIMETER SETTING INDICATOR. VOLUME I. Final Report. Sellers, B.; Morel, P. (Panametrics, Inc., Waltham, Mass.). Jun 1969. Contract FA-67-WA-1659. 90p. (FAA-RD-69-38-1). CFSTI.

A need exists for an altimeter setting indicator system capable of operating up to ten digital displays and having an indicated error of plus or minus .005 inches of mercury. This report presents the results of a design and development program having the objective of determining the feasibility of using a radioisotopic source as the basic sensing element in such a system. The isotopic source selected for use in this system is the 5.5 MeV alpha emitter, americium-241, whose half life is 458 years. The basic parameter measured by this, and other isotopic emitters, is density. Thus, in order to make a measurement of pressure by direct sensing with such a source, it is necessary either to place the sensor in a controlled temperature enclosure which is connected to the point at which pressure is to be measured, or to monitor the temperature in the enclosure and utilize that information along with the density

to calculate the pressure. The temperature must either be controlled or measured to an accuracy of about ±.02C to meet the design objective on pressure. The approach utilized in the present system was that of a controlled enclosure. (auth) (USGRDR)

**16906** PORTABLE BETA BACKSCATTER TYPE MEASURING INSTRUMENT. Weinstock, Jacques J.; Wade, Donald E.; Lieber, Sidney U.; Hay, William D. (to Unit Process Assemblies, Inc.). U. S. Patent 3,496,359. 17 Feb 1970. Filed 9 Feb 1966.

A portable beta backscatter measuring instrument is described having a pencil probe assembly displaceably mounted within the bore of a weighted transparent guide member with positioning indices on the lower surface thereof to permit blind positioning of the probe assembly in desired positional relationship with the specific portions of a workpiece to be subject to measurement. (Offic. Gaz.)

**16907** APPARATUS FOR MEASURING HYDROGENOUS MATERIAL UTILIZING RADIOACTIVE SOURCE. Lowery, Andrew; Clements, Richard F. (to Troxler Electronic Labs., Inc.). U. S. Patent 3,492,479. 27 Jan 1970. Filed 2 May 1966.

A portable nuclear measuring apparatus which incorporates a fast neutron source and a slow neutron detector located in a shielded housing having a movable shielded drawer adapted to move in and out of the housing and to support a removable pan is described. A uniform sample of a nonradioactive material such as heated asphalt, a concrete mixture or the like is placed in the pan externally of the apparatus, the pan is placed on the drawer and the drawer is moved into the housing to expose the material to the source radiation and by utilizing neutron moderation phenomena and measuring slow neutrons produced therefrom determine the hydrogenous content of the material. (Offic. Gaz.)

**16908** METHOD FOR MEASURING ELONGATION BY NEUTRON ACTIVATION. Hasegawa, Akio (to Fujitsu Ltd.). Japanese Patent 1969-21924. 19 Sep 1969. Filed 12 Mar 1966.

The method proposed, utilizing neutron activation, can measure simultaneously the elongation in length and width of a film of organic material during the rolling process. The method consists of three parts: (1) a means for labeling the film by neutron activation; (2) a means for measuring the elongation in width; and (3) a means for measuring the elongation in length. (1) includes the following: a neutron generator to label the film by activation located above the film; a radiation detector to detect the induced radioactivity, located downstream; and a control to operate the neutron generator by means of the output of the radiation detector for labeling the film at regular intervals. (2) includes the following: a pair of detectors located downstream from the labeling detector to detect the radioactivities in width; and the output annunciators to the respective detectors. (3) includes a series of an a.c. generator connected to the film-conveyor rollers, a gate circuit, and a counter. The elongation in length is measured through the indication of the a.c. generator output-wave by opening the gate circuit with the detection output and closing it with the output of the control. (NSA of Japan)

**16909** CALCULATION OF NON-PARALLELISM OF GAMMA ACCESS TUBES, USING SOIL SAMPLING DATA. Rijtema, P. E. (Inst. for Land and Water Management Research, Wageningen, Netherlands). J. Hydrol.; 9: 206-12(Oct 1969).

Use of the $\gamma$-ray transmission method to measure the variation in soil moisture content is discussed. Results of the $\gamma$-ray transmission technique are very sensitive to small errors in distance between source and detector. An indication of nonparallelism of both access tubes can be obtained by comparing the data of soil sampling with the results obtained from the $\gamma$ transmission method. However, the main difficulty remains the separation between the systematic error, due to nonparallelism and the random variation due to sampling errors and soil heterogeneity. This random variation can be greater than the systematic error due to nonparallelism. A method to calculate the systematic errors due to nonparallelism of the access tubes is presented. Data outlined under dry and wet conditions are given, as well as the uncorrected and corrected values of the change in moisture content. A table also presents the original and the corrected values of the absolute moisture content. The change in moisture of the whole profile according to the original data is 88.6 mm, whereas it is 90.8 mm after correction. The error due to nonparallelism is 2.5%. The error in the separate layers varies from 0 to 4.5%. As the systematic error affects all measured data in a given layer in the same direction, the effect of nonparallelism on the determination of changes in moisture content is not very critical. Under the presented conditions of nonparallelism the errors in the absolute moisture contents are in the order of 10 to 20% of the original moisture content. (BBB)

**16910** RADIOMETRIC METHOD FOR INVESTIGATING ZONES OF LOOSENED ROCK. Charbucinski, Jacek; Gajoch, Krzysztof. Rudy Metale Niezelaz.; 14: 633-6(Nov 1969). (In Polish).

A radiometric method for investigating ground mass loosening with the aid of a bore-hole densimeter of the GO type is described. The physical principles involved and the measurement methods are discussed. Results of laboratory investigations carried out on models and in a calcareous-dolomite longwall roof of the Lubin mine confirmed the method to be well suited for rock loosening measurements. (auth)

**16911** ARRANGEMENTS FOR DETERMINING THE MOISTURE CONTENT OF SOLID SUBSTANCES BY MEANS OF NEUTRON IRRADIATION. (to Rheinische Kalksteinwerke GmbH). British Patent 1,180,450. 4 Feb 1970. Filed 17 Mar 1967.

The arrangement described is a modification of that covered by British Patent 1,063,477. In the modified arrangement the thermal neutron counting device is screened from the reflector material by a material which absorbs thermal neutrons. The screening material may be of Cd, B, Gd or compounds or alloys thereof, the balance of any such alloy being Fe or Al. Screening of the counting device in this way considerably improves the measuring sensitivity of the arrangement. (UK)

**16912** DEPTH AND PROFILE PATTERN MEASURING DEVICE FOR BLAST FURNACES. Frevert, E. (Oesterreichische Studiengesellschaft fuer Atomenergie GmbH, Seibersdorf, Austria). Isotopenpraxis; 5: 403-8(Nov 1969). (In German).

A device is proposed giving both depth measurement and information on profile pattern by obliquely transmitted radiation from a radioactive isotope. Four detectors are provided for each of three planes of measurement with a perpendicular spacing of 500 mm. The two $^{60}$Co sources are placed above each of the three planes, the source strength is 3 Ci each. Detectors and radiation sources are located in such a manner that, in view from above, a regular octagon is formed. The selection of the source strengths is discussed. The circuit diagram of the electronic data recording, processing, and reading device is given. Time control of the device is realized by a reference measuring section equalizing the activity decay of the sources due to the $^{60}$Co disintegration time. (auth)

## Miscellaneous Instruments and Components

*Refer also to abstracts 17212, 18056, 18288, 18327, 18472, 18699, 18709, and 18788.*

**16913** (CERN-70-4) HIGH-FREQUENCY AND PULSE RESPONSE OF COAXIAL TRANSMISSION CABLES WITH CONDUCTOR, DIELECTRIC, AND SEMICONDUCTOR LOSSES. Riege, H. (European Organization for Nuclear Research, Geneva (Switzerland)). 4 Feb 1970. 33p. Dep. CFSTI (U. S. Sales Only).

The distortion of arbitrary pulses is computed for coaxial transmission cables with different kinds of losses. Starting from cables with normal skin effect losses, formulae for attenuation and rise-time of rectangular and nearly rectangular pulses are developed. The theory of combined conductor and dielectric losses is reviewed. Furthermore, the contribution of additional conducting or semiconducting layers to the losses in high-voltage pulse cables is investigated. By use of Maxwell's equations, the propagation constants in the frequency domain are calculated. For coaxial cables with semiconducting layers also an approximate solution in the time domain is presented, by which the distortion of arbitrary pulse shapes can be numerically computed. (auth)

**16914** (CONF-690910-, pp 307-29) HIGH TEMPERATURE THERMAL CYCLING AND DRIFT TEST OF $W_{95}$ $Re_5$ VERSUS $W_{74}$ $Re_{26}$ THERMOCOUPLES. Schwarzer, D. E. (Gulf General Atomic, Inc., San Diego, Calif.).

The requirement to monitor the fuel temperatures of in-pile fuel material irradiations necessitated the use of high temperature thermocouples. Due to the high loss rate of commercially fabricated thermocouple units, Gulf General Atomic proceeded to develop and test their "in-house" fabricated thermocouples using $W_{95}$ $Re_5$ versus $W_{74}$ $Re_{26}$ sensor wires. A tantalum swaged hot junction with various multi-sensor wire configurations is described as are the test results. Thermocouple calibrations were accomplished prior to thermal cycling from 1800°C to < 500°C, after thermal cycling and after a 500 hour life test at 1650°C. Test results indicated that the thermal emf of the tested thermocouples were in agreement with the published millivolt output data and that stable output was maintained after many thermal cycles and for

long periods of time at high temperature. The test apparatus is described as are the post-test examination results of the thermocouples, showing the impurities in two different samples of beryllia used in testing. Metallographic examination of the swaged tantalum plug and sensor wires showed no contamination and also that a good contact was maintained between adjacent thermocouple wires. Two short term tests of 155 and 100 hours at 1650°C using $W_{97}$ $Re_3$ versus $W_{75}$ $Re_{25}$ as the sensor wires are briefly discussed. These sensor wires were in the same four wire, four slot configuration as those used for the 500 hour life test. The test results also agreed with published data and were stable over the lifetime of the test. No failure occurred during any of the testing. (auth)

**16915** (COO-614-71) ICR QUARTERLY REPORT NUMBER 22. Yngve, Victor H. (Chicago Univ., Ill. Inst. for Computer Research). 1 Aug 1969. Contract AT(11-1)-614. 99p. Dep. CFSTI.

The program simulation facilities which have been implemented on Maniac III to allow software to be coded and debugged for the yet to be completed multicomputer system are described. A detailed specification of the simulator assembly language accepted by Assembler 3.5 is presented. Also, three short papers are included entitled "Unnormalized floating-point arithmetic as approximate interval arithmetic," "Search for pulsing supernova," and "Exact probabilities of a voter's paradox through seven issues and seven judges." (W.H.K.)

**16916** (EUR-4399) DESIGN AND TESTING OF A MEASURING HEAD FOR X-RAY FLUORESCENCE ANALYSIS BY MEANS OF RADIOACTIVE SOURCES. Final Report. Broquet, C.; Merrer, P. (Atome Industriel, Orsay (France)). 1969. Contract 111-67-4-IRAF. 100p. (In French). Dep. CFSTI.

Many industrial analyses can be carried out non-destructively by means of X-ray fluorescence using a radioactive source. The aim of the present study was to design and construct a measuring head which in combination with a single-channel amplitude selector and a count scale could be employed as a portable appliance. As a result of the study the following solutions were decided on: the use of a NaI scintillating crystal and a photomultiplier for the detector, source mounted eccentric to the sample-carrier window, selection of X-rays by a combination of balanced filters and a single-channel selector, preamplifier and VHT supply to be incorporated in the measuring head. Stability and sensitivity threshold tests gave satisfactory results. The examples dealt with were the assay of Cu, Ca and Sn in an aqueous solution, Fe and Ca in ores, and Zn in brass. The results obtained can, moreover, be improved by optimizing the characteristics of the head, the principal parameters of which are discussed. (auth)

**16917** (MSAR-70-2) EFFECT OF HIGH-TEMPERATURE SODIUM ON THE MECHANICAL PROPERTIES OF CANDIDATE ALLOYS FOR THE LMFBR PROGRAM. DEVELOPMENT OF A HIGH-TEMPERATURE EXTENSOMETER DEVICE FOR USE IN 1200 F LIQUID METAL SERVICE. Topical Report No. 17. Green, Daniel A.; King, Earle C. (MSA Research Corp., Evans City, Pa.). Jan 1970. Contract AT(11-1)-765. 27p. Dep. CFSTI.

The design specifications, calibration, and testing of an extensometer for operation in liquid sodium at 1200°F are described. The extensometer employs a linear variable differential transformer located in the liquid sodium system. (W.H.K.)

**16918** (NYO-3661-27) FAST-FAST COINCIDENCE DUAL RANGE TIME-TO-AMPLITUDE CONVERTER SYSTEM. Tao, S. J. (New England Inst., Inc., Ridgefield, Conn.). Nov 1969. Contract AT(30-1)-3661. 14p. Dep. CFSTI.

A fast-fast coincidence time-to-amplitude system with two time-to-amplitude converters, one of range 40 nsec and another, 400 nsec, is described. This system is found to be very useful in the determination of positron annihilation lifetime spectrum in non-condensed materials where a long range and a good resolution are both required. By using this system both the memory space required and the labor for data reduction are considerably reduced. (auth)

**16919** (UCRL-19402) SOME EXPERIENCES WITH PULSE HEIGHT ANALYSIS USING A DISK. Jenson, David W. (California Univ., Berkeley. Lawrence Radiation Lab.). Nov 1969. Contract W-7405-eng-48. 9p. (CONF-691110-2). Dep. CFSTI.

From Fall Symposium of Digital Equipment Computer Users Society, Las Vegas, Nev.

A partial description of two systems for pulse-height analysis that store histograms on a movable-head disk is given, with emphasis on techniques for continuously updating histograms stored on a disk and for controlling data flow through asynchronous parallel processes of differing priorities. One of the systems is capable of updating 16,384 channels of histogram on the disk at a continuous rate of 750 events per second using a PDP-5. Some projected data-handling rates for a PDP-8 and a head-per-track disk are given. (auth)

**16920** (UCRL-72193) AN FM ACCELERATION/VELOCITY MEASUREMENT SYSTEM. Spataro, Sam (California Univ., Livermore. Lawrence Radiation Lab.). Feb 1970. 36p. (CONF-700302-1). Dep. CFSTI.

From Instrumentation for Nuclear Weapon Effects Symposium, Albuquerque, N. Mex.

A constant bandwidth measurement system using a variable reluctance accelerometer or velocity transducer to frequency modulate a dual-oscillator, balanced modulator circuit is described. Features include a remote calibration capability in the oscillator and the ability to use the same electronics for a variety of transducers. As associated signal conditioner and constant current regulator provides power to as many as six transducer-oscillators, multiplexes the carriers with a reference frequency, and delivers them to an end recorder or telemetry link. Data are played back through standard discriminators and digitizing equipment and are processed by a computer which yields time history plots of acceleration, velocity, and displacement. This system is used for measuring ground motion induced by nuclear detonations. (auth)

**16921** CALCULATION OF PENETRATION FACTORS FOR POINT GAMMA-RAY SOURCES OFF THE AXIS OF CYLINDRICAL HOLE COLLIMATORS. Bell, T. K. (Royal Victoria Hospital, Belfast); Spiers, E. W.; Johnston, A. R. Phys. Med. Biol.; 15: 47-56(Jan 1970).

Expressions are derived for the effect of γ-radiation penetrating the walls of a cylindrical collimator when the emitting point source is off the collimator axis, taking into consideration the diameter and effective thickness of the detector. The expressions are evaluated by a Monte Carlo technique and response curves for varying source position are presented for five different absorption coefficients and two sizes of collimator. (auth) (UK)

**16922** A COMPUTER METHOD FOR CALCULATION OF THE POINT SOURCE RESPONSE OF A FOCUSING COLLIMATOR. Simons, H. A. B. (Royal Free Hospital, London). Phys. Med. Biol.; 15: 57-70(Jan 1970).

A digital computer is used with a ray tracing technique to calculate the response of a multihole focusing collimator to a point source of radiation placed anywhere in the object space. The analysis is applicable to a focusing collimator with circular holes and includes both the geometrical contribution to the response and the effects arising from both edge and septum penetration. The results are presented as the solid angle subtended at the point source by the effective exit pupil of the collimator and may be calculated as a function of the linear absorption coefficient of the collimator material. The method of testing the computer programs used to solve the equations arising from ray tracing is described. The point source response of the 19-hole Picker Type 2107 collimator for 3 different quantum energies is calculated. The results are compared with those previously published. The responses for a single taper hole collimator and for a series of seven-hole collimators differing from each other only in septum thickness, each hole again having the same dimensions as the 2107, are calculated. It is concluded that the major contribution to the count rate with the 2107 collimator from penetrative effects is by edge penetration and not by septum penetration. (auth) (UK)

**16923** QUARTZ CRYSTAL MONITORING FOR OPTICAL THIN FILMS. Clapham, P. B.; Downs, M. J.; Raine, K. W. (National Physical Lab., Teddington, Eng.). Thin Solid Films; 4: R39-42(Nov 1969).

The relative sensitivity of a quartz crystal oscillator for monitoring the thickness of various optical thin films was studied. It was concluded that, provided reasonable care is taken in calibration and use, a monitoring accuracy can be attained which is adequate for a wide variety of optical thin film designs. (W.H.K.)

**16924** METHOD AND APPARATUS FOR THE EXAMINATION OF SAMPLES OF NUCLEAR FUEL OR WHOLE FUEL ELEMENTS WITHOUT DESTRUCTION THEREOF. Weinzierl, Peter; Putz, Franz (to Osterreichische Studiengesellschaft fuer Atomenergie GmbH). U. S. Patent 3,496,357. 17 Feb 1970. Priority date 9 Nov 1964, Austria.

A method for detecting and measuring the quantity present in a composition of a nuclei having at least one resonance absorption cross-section is described comprising the steps of providing a source of neutrons having an energy spectrum extending across the energy band of at least one resonance absorption cross-section of the nuclei to be measured, measuring the energy spectrum in a detector, impinging the neutrons upon a composition containing the nuclei to be measured, measuring the energy spectrum of the neu-

tron radiation emanating from the composition, and comparing it with the first-mentioned measured energy spectrum to detect and provide a measurement of the quantity of the nuclei present in the composition. (Offic. Gaz.)

**16925** LASER INTERFEROMETER FOR HIGHLY TRANSIENT PLASMA DIAGNOSTICS. Rowley, Paul D. (Ames Research Center, Moffett Field, Calif.). Rev. Sci. Instrum.; 41: 313-18 (Mar 1970).

A description is given of a modified Michelson interferometer that is particularly useful for locally probing highly transient plasmas such as occur behind incident shock waves in high performance shock tubes. The interferometer has the following features: (a) It is of a modified Michelson form with spherical mirrors to minimize effects of spatial variations in the index of refraction normal to the beam, (b) the light source is a cw laser that provides a very narrow coherent beam to allow high spatial and temporal resolution of the probe, and (c) it is operated in a single fringe mode over the narrow beam (constant phase difference between the two interfering beams over the illuminated field) and fringe shifts are observed through the time response of single channel detectors. Because photon transit time is negligible in shock tube diagnostics, the response time of the interferometer is determined solely by detection capabilities. Rapid response is achieved because nearly the entire laser energy is available for detection and high contrast interference takes place, allowing high signal-to-noise ratios at wide bandwidths. The spatial resolution can be diffraction limited. Thus, one-dimensional observations can be made of temporally and spatially varying events with a combined temporal and spatial resolution exceeding that available with other current interferometric techniques. Index of refraction profiles behind strong shock waves have been observed at two wavelengths simultaneously and verify the usefulness of the design. A further design modification is discussed which removes the uncertainty in the sign of the temporal gradient of index of refraction and would allow accurate fractional fringe interferometry. (auth)

**16926** DESIGN AND PERFORMANCE OF A PULSE RADIOLYSIS SYSTEM CAPABLE OF PICOSECOND TIME RESOLUTION. Bronskill, M. J.; Taylor, W. B.; Wolff, R. K.; Hunt, J. W. (Univ. of Toronto). Rev. Sci. Instrum.; 41: 333-40(Mar 1970).

A unique stroboscopic pulse radiolysis system is described which detects the transient light-absorbing species formed in solutions by individual fine structure pulses from a 40 MeV linear accelerator. A measured time resolution of 23 psec is attained by using, as the analyzing light, the short (<10 psec) Cherenkov light flashes produced in air by the fine structure pulses of the electron beam. This light is suitably delayed by an optical system in which the path length is slowly changed, then passed through the irradiated sample. The integrated light passing through the sample is detected, and variations in the optical absorption at varying times after the irradiation pulse are observed. The design and performance of the optical, mechanical, and electronic devices which retrieve the absorption signal out of the noise are described in some detail. As an integrated unit, this system meets its expected performance capability, being able to successfully detect absorption signals as small as 0.2%. (auth)

**16927** CROSSED FIELD VELOCITY ANALYZER FOR PLASMA IONS. Bastian, C.; Cosler, A. (EURATOM-KFA, Juelich, Ger.). Rev. Sci. Instrum.; 41: 365-9(Mar 1970).

A crossed electric and magnetic field analyzer has been developed to select ions of a given $m_i/q$ ratio and record their velocity distribution. The initial velocities of the ions are mainly directed along the magnetic field of the analyzer; the detection is performed in a plane perpendicular to it. The ion optical properties of the analyzing structure and its sensitivity to space charge effects are illustrated by the synoptical recordings of the velocity distributions of protons leaving a conical theta pinch plasma accelerator. The velocity spectrogram appeared on an ion sensitive plate positioned in the detection plane, showing a series of well focused images of the inlet. In some cases, the particle density in the proton beam could be deduced from the features of the spectrogram. (auth)

**16928** FAST ACTING ALL-METAL GAS VALVE FOR PLASMA RESEARCH. Novak, B.; Pekarek, S. (Technical Univ., Prague). Rev. Sci. Instrum.; 41: 369-73(Mar 1970).

A fast acting, all-metal valve has been developed for injecting pulses of neutral gases into a high vacuum. The theoretical motion of the piston is analyzed and compared with its actual dymamic and electrical operating characteristics. The design of the valve makes it possible to change the length of time the valve is open and thus vary the number of atoms admitted. Preliminary measurements of the pressure in the gas pulses have been made with fast stabilized ionization gauges. Reproducibility of measurement of the operating times of valve and gas pressure pulses was better than 95%. The gases used were hydrogen, helium, argon, and nitrogen. (auth)

**16929** STUDIES OF A PLASMA WIND TUNNEL FOR SIMULATING THE COLLISIONLESS BOW SHOCK OF THE EARTH. Condit, William C. Jr. (Cornell Univ., Ithaca, N. Y.). Rev. Sci. Instrum.; 41: 374-80(Mar 1970).

Formulas are given for the plasma density and velocity required to simulate the flow of the solar wind over the magnetosphere of the earth. A description of a plasma source (coaxial arc-jet) intended to produce appropriate plasma flows is given. The operation of the device is described. Preliminary measurements of the density and velocity, made with a bolometer and a ballistic pendulum, indicate that plasma densities of $10^{13}/cm^3$ and velocities of $10^7$ cm/sec have been achieved in a jet of 1 m diameter. These parameters have been verified by microwave and Langmuir probe measurements and are appropriate for the desired simulation. In addition, it has been shown for the first time that this plasma has the required percentage ionization for solar wind simulation. (auth)

**16930** RATIO PYROMETER FOR USE IN Q-MACHINES. Guilino, E.; Mueller, P. (Institut fuer Plasmaphysik GmbH, Munich). Rev. Sci. Instrum.; 41: 429-34(Mar 1970).

A new ratio pyrometer is described the indication of which is proportional to the ratio of intensities of thermal radiation emitted by an incandescent object into two narrow spectral bands within the visible region. The ratio is computed automatically and continuously by servoattenuating the entire incoming light flux in such a way that the intensity in one of the two passbands is kept constant, regardless of the intensity of the incoming light. Due to its basic principle the instrument reading is independent of the magnitude of the target emissivity. In the present setup, temperature differences of the order of 1° can be resolved in a temperature range between 1400 and 2900°K. Thus the pyrometer is especially suited for investigation concerning plasma confinement in Q-devices. (auth)

**16931** PROGRAMMED DIGITAL IC PULSE GENERATOR FOR TRANSIENT NMR SPECTROMETRY. Franconi, C.; Terenzi, M. (Univ., Cagliari, Italy). Rev. Sci. Instrum.; 41: 456-61(Mar 1970).

A pulse pattern generator for NMR spectrometry using SGS micrologic IC's for the logic and counters is described. Time intervals between pulses, gate times controlling the number of pulses in a sequence, and delay times controlling the sequence repetition rates are all digitized. Auxiliary pulse outputs to use as suppression pulses, for controlling delay lines, and for gated signal averaging devices are provided. The pulse sequences are those most commonly used in relation times measurements, including $T_{1\rho}$. The generation of further sequences and the possibilities of using the flexible logic of this apparatus for extending its use are discussed. (auth)

**16932** A METHOD FOR PROVIDING PRECISE SWEEP CALIBRATIONS SIMULTANEOUS WITH THE RECORDING OF MAGNETIC RESONANCE SPECTRA. Cohen, E. A.; Manatt, S. L. (California Inst. of Tech., Pasadena). Rev. Sci. Instrum.; 41: 473-4(Mar 1970).

A simple device and a straightforward method of achieving precise, accurate, and permanent calibration of a high-resolution NMR spectrum simultaneous with permanent recording of the spectrum are described. A method based on the technique of beating an unknown frequency against a known very stable standard is used for precise calibration. (C.E.S.)

**16933** SOFT X-RAY SPECTROMETER WITH IMPROVED DRIVE. Cuthill, J. R. (National Bureau of Standards, Washington, D. C.). Rev. Sci. Instrum.; 41: 422-3(Mar 1970).

The spectrometer described is a grazing incidence grating instrument with an improved drive system for moving the electronic detector around the Rowland circle. In this system the lead screw driving the detector always lies along a chord of the Rowland circle joining the grating and the detector. With this design there is less chance of error due to flexure of the components than in previous designs, and the resolution of the spectrometer is constant in wavelength. (auth)

**16934** NUCLEAR INSTRUMENT MODULES AT THE JAPAN ATOMIC ENERGY RESEARCH INSTITUTE. Kinbara, Setsuro; Kumahara, Tadashi (Japan Atomic Energy Research Inst., Tokai, Japan). Nippon Genshiryoku Gakkaishi; 11: 726-34(Dec 1969). (In Japanese).

Technical information on the nuclear instrument module system used in the Japan Atomic Energy Research Institute (JAERI) for general nuclear experiments is presented. This JAERI module system accords with the NIM standard adopted in 1966 by the USAEC. Already in JAERI nearly 1,000 units of the module representing 47 varieties, have been produced and supplied to various

laboratories in JAERI. The module system possesses many features embodied in the pulse shape discriminating circuit, the time pickoff circuit and the high resolution spectrometry system. A description is given of these features, and also of the circuit configuration and characteristics of these units, which include general purpose nuclear instruments. (auth) (NSA of Japan)

**16935** A "WARBURG" RESPIROMETER FOR MEASUREMENTS UNDER CONTINUOUS IRRADIATION. Trampisch, W.; Kiefer, J.; Waldvogel, H.; Sattler, E. L. (Institut fuer Biophysik, Giessen, Ger.). Experientia; 25: 1227(15 Nov 1969).

For investigations of recovery phenomena in microorganisms, respiration rates under continuous x irradiation were measured in situ and without handling the samples. A special Warburg respirometer incorporating an x-ray tube mounted below its water bath was designed. Both the Warburg assembly and the x-ray tube were enclosed in a 5 mm lead sheet. The manometric recorder used provided for seven simultaneous traces. The x-ray beam from the tube was collimated by a 5 mm lead applicator. Isodose curves were measured in air using a thimble-chamber and a Siemens dosimeter. (H.L.W.)

**16936** METHOD OF IN-PILE CALORIMETRY GAS DUMPING METHOD. Hayashi, Takao; Kudoh, Mitsuo (Japan Atomic Energy Research Inst., Ibaraki). J. Nucl. Sci. Technol. (Tokyo); 7: 51-3(Jan 1970).

A method of in-pile calorimetry is proposed based on an original concept utilizing vacuum thermal resistance and gas dumping. Experiments have given accurate results, indicating that the method might eventually be developed into a practical probe for measuring $\gamma$-heating rate in the core and especially effective in measuring higher $\gamma$-heat as generated in the reactor core such as the JMTR or fast breeder reactor. The method can further be expected to be utilizable also in evaluating the heat generation from samples in capsule irradiation. (W.H.K.)

**16937** REMOTE CONTROL OF A POLARIZED NEUTRON GONIOMETER BY A SMALL COMPUTER. Ledebt, Ph.; Poussin, M.; Muttel, J.; Roudaut, E. (CEN, Grenoble, France). Bull. Inform. Sci. Tech. (Paris); No. 143, 15-19(Dec 1969). (In French).

The increasing number of parameters to be supervised on diffractometers and the growing complexity of angular displacement programs have led to the introduction of digital techniques and the mounting of a small computer, for neutron diffraction on a polarized neutron goniometer. A PDP-8S computer chosen to supervise a goniometer with five angular displacement axes is described. This computer also controls the counting of incident and reflected beams and the polarization of the neutrons. (auth)

**16938** CORRELATORS IN MEASUREMENTS TREATMENT AND SPECTRAL ANALYSIS. Max, Jacques; Fauque, Jean-Marc; Berthier, Daniel (CEN, Grenoble, France). Bull. Inform. Sci. Tech. (Paris); No. 143, 21-51(Dec 1969). (In French).

The French Atomic Energy Commission (C.E.A.) has studied, tested and produced two types of automatic real-time correlators, on industrial scale, covering a range of frequencies from 0 to 5 Megahertz. These apparatuses simultaneously supply up to 400 points of the function of correlation. The theory of the method is discussed, and several examples of its applications in different fields are given. Further it is reported that the method of correlation (by the association of a correlator and Fourier's transformer) is actually the only device which permits, in real time, the determination of the densities of energy spectra in the range of frequencies from 0 to 5 MHz; this last limit is susceptible to increase. (auth)

## Radiation Effects on Instruments and Instrument Components

*Refer also to abstract 17404.*

**16939** (AD-695420) GENERATION OF MECHANICAL VIBRATIONS BY PENETRATING PARTICLES. Beron, B. L.; Hofstadter, R. (Stanford Univ., Calif. High-Energy Physics Lab.). Jun 1969. Contract Nonr-225(67). 9p. (HEPL-604). CFSTI.

Mechanical, or sound, vibrations were observed in ceramic piezoelectric disks of lead-zirconate-titanate (PZT) struck by high energy electrons. Four ½ inch thick disks of PZT were used. A wide band, low impedance, common base configuration amplifier was used to examine the induced vibrations. Since the most prominent resonant frequencies of the disks were near 40 kHz (radial mode) and 158 kHz (compressional mode) most of the studies were concentrated on these modes. Electrons of energy 1.00 BeV and 0.20 BeV were used in pulses, each lasting about 1.0 microsecond and contained 10,000 to 1,000,000 electrons. The cross section of the incident 1.00 BeV beam was about 3 mm × 3 mm. (auth) (USGRDR)

**16940** (COO-1624-21) FAST NEUTRON EFFECTS ON TRANSISTOR SCATTERING PARAMETERS. Gray, David Leslie (Missouri Univ., Rolla). 1969. Contract AT(11-1)-1624. 99p. Dep. CFSTI.

Thesis.

It has not been possible in the past to characterize a transistor or other semiconductor device with regard to its performance in a fast neutron (E > 10 keV) environment when the device is operated at high (>100 MHz) frequencies. Using the scattering (s-) parameter concept, which regards a device as a two-port "black box," a full characterization of the trends in the neutron bombarded high-frequency performance of a typical transistor can be made. Scattering parameters are not only an accurate means of describing the high-frequency performance of any device, but are now reasonably easily measured with the advent on the market of reliable, highly accurate s-parameter test sets. Methods which exist to permit the rapid design of high-frequency transistor circuits, once the device scattering parameters are known, are reviewed. The effects of neutron bombardment on a high-frequency transistor amplifier are found to be generally enhancing, rather than degrading as expected, if the device is operating near or above the published minimum $f_T$. (auth)

**16941** DIGITAL LOGIC FOR RADIATION ENVIRONMENTS: A COMPARISON OF METAL/OXIDE/SEMICONDUCTOR AND BIPOLAR TECHNOLOGIES. Dennehy, W. J. (RCA Astro-Electronics Div., Princeton, N. J.); Holmes-Siedle, A. G.; Zaininger, K. H. RCA Rev.; 30: 668-708(Dec 1969).

In analyzing the impact of radiation environments on logic circuitry constructed of MOS and bipolar transistors, one must consider the magnitude and relative importance of two very different classes of phenomena—permanent effects and transient effects. The phenomenology of these two classes of effect is reviewed. a detailed analysis of a typical pair of existing, competing circuit designs is presented, and the advantages that are likely to result from recent improvements in device technology are described. These improvements include (1) the use of aluminum oxide as the MOS gate-insulator material in place of silicon dioxide and (2) the adjustment of the geometry of certain "critical junctions" in MOS devices. These advances are discussed in relation to the overall problem of hardening integrated circuits for pulsed and steady-state radiation environments. It is concluded that, although some current designs of MOS logic device may have a sensitivity to permanent damage that is a serious problem in some expected radiation situations in space, MOS technology has a high potential for producing very "hard" circuits and systems. (auth)

**16942** THE EFFECT OF NEUTRON IRRADIATION ON THE TRAPATT DIODE. Chaffin, Roger J.; Eer Nisse, Errol P.; Hood, Jerry A. (Sandia Labs., Albuquerque, N. Mex.). Proc. IEEE (Inst. Elec. Electron. Eng.); 57: 2063-4(Nov 1969).

Measurements have been made of neutron irradiation effects on the trapped plasma avalanche triggered transit (TRAPATT) microwave device. Results show that for levels up to $10^{15}$ neutrons/cm$^2$ (energy >10 keV) there is little change in the diode RF parameters. The observed degradation above this level is described. (auth)

**16943** APPLICATIONS OF JUNCTION COMPENSATION TECHNIQUES IN REDUCING TRANSIENT GAMMA RADIATION EFFECTS IN TRANSISTOR CIRCUITS. Boatwright, Lewellyn T. Jr.; Davis, Goebel Jr.; Grannemann, Wayne W. Contract ONR N00014-A-0158. IEEE (Inst. Elec. Electron. Eng.), Trans. Electron Devices; ED-16: 912-16(Nov 1969).

Any transistor exposed to transient gamma radiation will produce a large transient photocurrent output pulse unless the circuit is hardened or protected against this effect. The hardening technique described in this paper consists of adding a reverse-biased junction between the collector and the base of a transistor, producing a photocurrent which cancels or compensates for the radiation-induced current. Both computer and experimental results show a significant hardening achieved by this method which is applicable to microcircuit systems as well as to discrete component systems. (auth)

# LIFE SCIENCES

## Biochemistry, Physiology, and Molecular Biology

*Refer also to abstract 16447.*

### Basic Processes

*Refer also to abstracts 16499, 17013, and 17133.*

**16944** RADIOISOTOPE AND RADIOCARBON CHARACTERIZATION OF BABOON KIDNEY FUNCTION DURING BLOODLESS, ISOLATED PERFUSION. Johnston, G. S. (Letterman General Hospital, San Francisco); van Heerden, P. D. R.; van Zyl, J. J. W.; Murphy, G. P. Transplant. Proc.; 1: 852-61 (Sep 1969).

Renal functional and isotopic studies were performed on baboon kidneys during isolated perfusion with exposure to 100% oxygen and 100% helium and in kidneys preserved with different mixtures of oxygen and helium under hyperbaric, hypothermic conditions. Renal functional results were better in kidneys exposed to high concentrations of helium. Oxygen had a vasoconstrictive effect on the cortical vessels with an increased resistance and decreased renal cortical flow, as measured by the extractions of PAH, creatinine, and electromagnetic arterial flow measurement. The $^{133}Xe$ clearance method clearly demonstrated the decreased cortical flow during oxygen-exposed perfusion and was found to be a very sensitive tool in assessing renal circulation. The distribution of labeled microspheres did not detect the difference in cortical flow during oxygen and helium exposure. $^{203}Hg$-chlormerodrin was equally concentrated both during oxygen and helium exposure presumably owing to the absence of plasma proteins in the perfusate. The kinetics of $^{203}Hg$-chlormerodrin may not be oxygen dependent. In kidneys preserved with high concentrations of helium $^{133}Xe$ clearance demonstrated a better cortical blood flow than in kidneys preserved with lower concentrations of helium. Some improvement in the preservation of kidneys on a short term basis may therefore be obtained through the use of an anoxic environment. (auth)

**16945** PURIFICATION OF RAT GAMMA BLOBULIN AND THE PRODUCTION OF A SPECIFIC ANTIRAT GAMMA GLOBULIN SERUM. Exum, Eurmal D.; Bowser, Robert T. (Armed Forces Radiobiology Research Inst., Bethesda, Md.). Proc. Soc. Exp. Biol. Med.; 133: 43-8(Jan 1970).

A method for the isolation of rat 7S gamma globulin using multiple adsorptions with DEAE-Sephadex A-50 is described. The procedure differs from that for human 7S globulin in terms of buffer pH and the number of adsorptions. Ultracentrifugal analysis indicated that the resultant fraction was a single component. Radioimmunoelectrophoresis ($^{59}Fe$) of the fraction against antirat serum confirmed the homogeneity of the 7S fraction. A nonspecific antiserum to rat 7S gamma globulin was produced that was free of reaction with all other serum components in electrophoresis against normal rat serum. (E.R.B.)

**16946** SURGICAL FORUM. VOLUME XX. Proceedings of the 25th Annual Session of the Forum on Fundamental Surgical Problems, 55th Clinical Congress of the American College of Surgeons, San Francisco, California, October 1969. Chicago; American College of Surgeons (1969). 579p. (CONF-691028-(Absts.)).

Separate abstracts were prepared on 12 papers. Two-hundred and sixty-eight additional papers report the results of other research studies in the field of surgery. (C.H.)

*For abstracts of individual papers see: 16947, 16959–16961, 17009, 17101–17106, and 17147.*

**16947** MEASUREMENT OF GASTRIN IN THE GASTROINTESTINAL MUCOSA BY RADIO-IMMUNOASSAY. Charters, A. Crane; Reeder, David D.; Thompson, James C. (Harbor General Hospital, Torrance, Calif. Univ. of California, Los Angeles). Surg. Forum; 20: 310-11(1969).

From 55th Annual Clinical Congress, San Francisco, Calif. See CONF-691028-(Absts.).

Gastrin concentration was measured in the gastrointestinal mucosa of the dog and man by radioimmunoassay. The concentration in the antrum was much higher than that found in fundus, duodenum, jejunum, ileum, or colon. The gastrin concentrations in the antral mucosa of puppies less than two weeks of age were significantly less than those found in adult dogs. (auth)

**16948** EFFECT OF CYCLOPHOSPHAMIDE ON THE IN VITRO PRODUCTION OF IMMUNE GLOBULINS BY LYMPHOID TISSUE IN ALLOGRAFT REJECTION. Phillips, Mildred E. (New York Univ., N. Y.). Proc. Soc. Exp. Biol. Med.; 133: 73-6(Jan 1970).

Immune globulin synthesis by sensitized lymph nodes, obtained from mice treated with cyclophosphamide, following the application of subcutaneous grafts of sarcoma I was studied by the technique of radioimmunoelectrophoresis. There was complete suppression of labeling of 7S $\gamma_1$ during the homograft reaction as well as almost complete suppression of immunoglobulin synthesis during the first 7 days after grafting. Labeling of 7S $\gamma_2$ and IgM appeared on the 10th day after the application of the graft. These findings differed from those obtained with untreated tumor-bearing murine hosts. (auth)

**16949** MEASUREMENT OF $^{14}CO_2$ ASSIMILATION IN SOILS: AN EXPERIMENT FOR THE BIOLOGICAL EXPLORATION OF MARS. Hubbard, Jerry S.; Hobby, George L.; Horowitz, Norman H.; Geiger, Paul J.; Morelli, Frank A. (Jet Propulsion Lab., Pasadena, Calif.). Appl. Microbiol.; 19: 32-8(Jan 1970).

A method is described for the measurement of $^{14}CO_2$ assimilation by microorganisms in soils. A determination involves exposing soil to $^{14}CO_2$, pyrolyzing the exposed soil, trapping the organic pyrolysis products on a column of firebrick coated with CuO, combusting the trapped organics by heating, and measuring the radioactivity in the $CO_2$ produced in the combustion. The detection of significant levels of $^{14}C$ in the trapped organic fraction appears to be an unambiguous indication of biological activity. The $^{14}CO_2$ that is adsorbed or exchanged into soils by nonbiological processes does not interfere. The method easily detects the $^{14}CO_2$ fixed by $10^2$ to $10^3$ algae after light exposure for 3 to 24 hr. Assimilation of $^{14}C$ is also demonstrable in dark-exposed soils containing $10^5$ to $10^6$ heterotrophic bacteria. Possible applications of the method in the biological exploration of Mars are discussed. (auth)

### Metabolism, Physiology, and Toxicology

*Refer also to abstracts 17010, 17014, 17076, 17147, and 17148.*

**16950** (COO-1181-1) THE RESPONSE OF THE RESPIRATORY TRACT AND LUNG TO INHALED STABLE AND RADIOACTIVE ISOTOPES OF CERTAIN ELEMENTS. Annual Technical Report, March 1, 1963–February 28, 1964. Berke, Harry L.; Vorwald, Arthur J. (Wayne State Univ., Detroit, Mich. Dept. of Industrial Medicine and Hygiene). Contract AT(11-1)-1181. 96p. Dep. CFSTI.

A single high dose of $^{152-154}Eu$ or $^{46}Sc$ aerosol was administered to mice and rats via inhalation. The animals were studied to determine the disposition of the inhaled aerosol in terms of tissue distribution, excretion, and retention. Pulmonary clearance mechanisms were also studied. The results of previous experiments using inhalation of high levels of aerosols of $^{152-154}Eu$, $^{46}Sc$, and $^{60}Co$ are presented. (C.H.)

**16951** (UCRL-50703) BIOLOGICAL AVAILABILITY IN THE DOG OF SOME RADIONUCLIDES PRODUCED BY A NUCLEAR EVENT. Chertok, Robert J.; Lake, Suzanne (California Univ., Livermore. Lawrence Radiation Lab.). 20 Nov 1969. 6p. Dep. CFSTI.

Nuclear debris produced by the venting of an underground nuclear event has been studied to determine the biological availability of some of the radionuclides. This debris was given orally to two spayed female beagles. These dogs were then analyzed daily for gamma-emitting radionuclides on a whole-body counter with a lithium-drifted germanium detector. Urine and feces were collected daily, sealed in tuna cans, and analyzed on the same counting system. All analyses were continued until very low levels of activity were reached. The radionuclides present included $^{99}Mo$, $^{132}Te$, $^{131}I$, and $^{103}Ru$. Two of these, $^{99}Mo$ and $^{131}I$, appeared to have been absorbed across the gut wall as indicated by their concentrations in the urine (27 percent and 30 percent respectively). Most of the $^{132}Te$ and $^{103}Ru$ was eliminated in the feces within the first two days. (auth)

**16952** THE EFFECT OF DTPA AND CALCIUM ON THE TRANSLOCATION OF INTRAPERITONEALLY ADMINISTERED $^{238}PuO_2$ PARTICLES. Saunders, C. L.; Bair, W. J. (Battelle-Northwest, Richland, Wash.). Health Phys.; 18: 169-73(Feb 1970).

Experiments on the influence of diethylenetriaminepenta acetic acid (DTPA) on the translocation of $^{238}PuO_2$ particles and the role

that calcium may play in this clearance process were carried out with rats. The implications these results may have on the early treatment of man with DTPA following an exposure to plutonium particles is discussed. (UK)

**16953** $^{241}$Am STUDIES IN BEAGLES. Lloyd, R. D.; Mays, C. W.; Taylor, G. N.; Atherton, D. R. (Univ. of Utah, Salt Lake City). Contract AT(11-1)-119. Health Phys.; 18: 149-56(Feb 1970).

Forty-eight adult beagles were injected with 0.00179 to 4.49 $\mu$Ci $^{241}$Am/kg body mass. Retained activity in the living animals was evaluated via the 60 keV gamma-ray using a combination of total-body and partial-body counting to determine the proportion in the liver and in non-liver tissue. Soon after injection, about 50% and 40%, respectively, of the administered $^{241}$Am was deposited in the liver and non-liver tissue (mainly skeleton). In the animals injected with 0.00179 to 0.305 $\mu$Ci/kg the liver and non-liver burdens decreased slowly each with a biological half-time of about 10 yr during the first 850 days. Two dogs injected with about 2.80 $\mu$Ci/kg exhibited a sharp decrease in liver retention beginning about 100 days after injection accompanied by an increase in non-liver $^{241}$Am. Both showed extreme degenerative liver changes at death 401 and 448 days after injection. Similar but more slowly progressing effects were observed in the retention of $^{241}$Am by two animals injected with about 0.904 $\mu$Ci/kg. Excreta collections from four dogs during the first three weeks after injection showed that $^1/_4$ of the excretion was urinary and that nearly $^3/_4$ of the total $^{241}$Am excreted during this period appeared in the first day's collection. Evaluation of the activity of individual bones, organs, and tissues of six animals autopsied 1 to 448 days after injection showed that although $^{241}$Am was distributed in many soft tissues, the liver and skeleton were the principal deposition sites; however, americium concentration in the thyroid gland was higher than in the skeleton and was higher than in any other soft tissue except the liver. Autoradiography showed that $^{241}$Am was deposited close to the location of the functioning thyroid cells. The kidney also had a relatively high concentration of activity, selectively deposited in the glomeruli. (auth) (UK)

**16954** PROTECTION OF THE CHROMOSOMES OF SEA URCHIN SCORPAENA PORCUS EMBRYOS FROM THE ACTION OF INCORPORATED $^{91}$Y WITH STREPTOMYCIN. Tsytsugina, V. G. (Inst. of the Biology of the Southern Seas, Sevastopol). Radiobiologiya; 9: 930-1(Nov-Dec 1969). (In Russian).

The protective effects of streptomycin in a concentration of 0.1 $\mu$g/liter on the chromosome apparatus of Scorpaena porcus L. embryos, developing from the stage of cleavage in a solution of radioyttrium with an activity of $6.1 \cdot 10^{-6}$ Ci/liter, were studied. The percentage of anomalous anaphases and telophases at the gastrula stage served as an index of radiation damage. A decrease in the injurious action of radioyttrium was noted in the presence of streptomycin. (tr-auth)

**16955** INFLUENCE OF INCORPORATED $^{89}$Sr ON THE INCORPORATION OF GLYCINE-2$^{14}$C AND $^{45}$Ca INTO DECALCIFIED TISSUES OF AUGUST RATS. Prokhonchukov, A. A. (Central Scientific Research Inst. of Stomatology, Moscow). Radiobiologiya; 9: 924-6(Nov-Dec 1969). (In Russian).

It was established in experiments on 174 August rats that under the influence of incorporated $^{89}$Sr at doses of 0.5, 1, 2, and 3 $\mu$Ci/g, the incorporation of glycine-2$^{14}$C and $^{45}$Ca into decalcified tissues at first is increased, and later decreases. When the dose of $^{89}$Sr is increased, the phase of activation decreases, while the phase of inhibition of exchange is intensified. The change in the exchange processes are more distinctly manifested in the bones than in the teeth. The disruption of the incorporation of glycine-2$^{14}$C is more pronounced than that of $^{45}$Ca. Disturbances of the processes of incorporation of glycine-2$^{14}$C and $^{45}$Ca precede the appearance of microscopic structural changes in the decalcified tissues. (tr-auth)

**16956** STUDY OF RIBONUCLEASE OF THE KINETICS OF EXCHANGE OF HYDROGEN–DEUTERIUM UNDER CONDITIONS OF DIMER FORMATION. Nonnenmacher, Genevieve; Coursaget, Jean (CEA, Gif-sur-Yvette, France). Compt. Rend., Ser. D, 268: 1976-8(Apr. 14, 1969). (In French).

The kinetics of the hydrogen–deuterium exchange when the deuterium was introduced by $CD_3COOD$ at 50% into deuterium oxide were followed. The theoretical number of exchangeable hydrogen atoms of ribonuclease was attained from the first determination (5 min.). The $CD_3COO-$ ions seem to facilitate the accessibility of some atoms which would be comparable with the hypothesis of the separation of a peptidic chain permitting the further formation of the dimer. (tr-auth)

**16957** DETERMINATION OF SERUM THYROXINE BY SATURATION ANALYSIS OF THYROXINE BINDING PROTEINS. Cuaron, Alfredo (Hospital General del Centro Medico Nacional, Mexico City). J. Nucl. Med.; 10: 532-9(Aug 1969).

A new method for estimating thyroxine concentration in serum based on the saturation of the thyroxine-binding proteins is presented. This procedure was assessed in sera from 487 patients and proved to be simple, accurate, economical and fast. It is not affected by iodine contamination since it is not based on chemical estimations of this element. It offers a direct measurement of thyroxine and is specific for this hormone. Its methodology is suitable for a small nuclear medicine unit equipped with a conventional well scintillation counter since it does not involve any chemical procedure and is simple enough to be performed by any person used to basic radioisotope methodology. It is a low-priced method compared with those previously reported since a Sephadex column is cheaper than the resin sponge and the same column can be used several times during a long period of time. Furthermore, this procedure uses the same labeled hormone used by the traditional in vitro thyroid tests and consequently does not increase costs by requiring the purchase of a wider variety of radiopharmaceuticals. It seems to be more accurate than the methods based on the use of a resin sponge because this procedure automatically excludes the radioactive iodide contaminating the stock solution of labeled triiodothyronine. Since it is an in vitro test, it does not expose the patient to ionizing radiation. Finally, its overall diagnostic accuracy is higher than that of the protein-bound iodine estimation when used during routine clinical work due to the high incidence of invalidation of protein-bound iodine estimation caused by iodine ingestion. (auth)

**16958** ABSORPTION, EXCRETION, AND TISSUE DISTRIBUTION OF ORALLY AND INTRAVENOUSLY ADMINISTERED RADIOCERIUM AS AFFECTED BY EDTA. Miller, J. K.; Byrne, W. F. (Univ. of Tennessee, Oak Ridge). Contract AT(40-1)-GEN-242. J. Dairy Sci.; 53: 171-5(Feb 1970).

Three pairs of calves fed 0, 1.35, or 13.5 g ethylenediaminetetraacetic acid (EDTA) per calf by capsule daily and one pair fed 13.5 g EDTA in milk through nipple pails were given intravenous $^{141}$Ce and oral $^{144}$Ce as simultaneous single doses. Oral $^{144}$Ce could not be detected in blood and intravenous $^{141}$Ce cleared rapidly with less than 16 and 0.6% remaining in blood 1 and 24 hr after dosing. Urinary $^{144}$Ce increased from 0.01% of the oral dose for controls to 0.21% when 1.35 g EDTA was fed. Percentages of the $^{144}$Ce dose in urine were further increased to 0.56 for calves fed 13.5 g EDTA by capsule and 1.21% for calves fed 13.5 g by nipple pail. Urinary $^{141}$Ce was raised slightly from 1.2% of the intravenous dose for controls to 1.6 by 1.35 g EDTA, to 5.27% by 13.5 g in gelatin capsules, and to 9.75% by 13.5 g given through nipple pails. Entry of intravenous $^{141}$Ce into the digestive tract occurred primarily in the small intestine. Fecal excretions and tissue distributions of both oral and intravenous doses were not statistically significantly changed by EDTA. Average 72-hr fecal excretions totaled 94 and 2% for oral and intravenous doses. Tissue $^{141}$Ce, expressed as percentages of the intravenous dose per 100 g, averaged: heart, 0.04; femur, 0.41; kidney, 0.23; liver, 2.60; lung, 0.75; rib, 0.13; and spleen, 0.67. Oral $^{144}$Ce was not detected in any tissue except the liver, which averaged 0.7% of the oral dose compared to 36.7% of the intravenous dose. (auth)

**16959** DISTRIBUTION AND LOCALIZATION OF RADIOIODINATED GASTRIN. Jaffe, Bernard M.; Newton, William T. (Washington Univ., St. Louis. John Cochran Veterans Administration Hospital, St. Louis). Surg. Forum; 20: 312-13(1969).

From 55th Annual Clinical Congress, San Francisco, Calif. See CONF-691028–(Absts.).

Radioiodinated $^{125}$I human gastrin was injected intravenously into 10 anesthetized dogs. Plasma and urine samples were collected at timed intervals and counted. Plasma and urine radioactivity associated with gastrin was determined by reaction with rabbit antibodies specific for the C-terminal tetrapeptide of gastrin followed by precipitation of the antibody-gastrin complex from plasma and urine by the addition of goat antirabbit gamma globulin. At 15 min and intervals from one to three hr, dogs were killed and samples of various tissues obtained were weighed, counted, and the space of distribution calculated. The tissue spaces were compared to data from five dogs who received free Na$^{125}$I. The lack of hepatic sequestration of $^{125}$I gastrin suggests that the liver inactivates little if any gastrin. This is consistent with previous studies in which endogenous gastrin was measured by radioimmunoassay simultaneously in hepatic and portal veins. The current experiments with exogenous radioiodinated gastrin demonstrate that gastrin shares three characteristics with other peptide hormones: short circulating half-life; low urinary clearance; and significant renal cortical sequestration and presumably inactivation. (auth)

**16960** IRRADIATION EFFECT ON COLLAGEN DEGRADATION. Weeks, Paul M. (Univ. of Kentucky, Lexington). Surg. Forum; 20: 498-9(1969).

From 55th Annual Clinical Congress, San Francisco, Calif. See CONF-691028-(Absts.).

Irradiation fibrosis may result from interference with collagen catabolism either directly or by altering collagen structure and thereby precluding collagenase recognition. The rate of collagenase activity, that is, in vivo degradation of collagen, is reflected by the rate of urinary hydroxyproline excretion. Results are reported from a study on the effect of a single dose of local x irradiation (1388 Rad) on the rate and total quantity of collagen degradation in rats a as measured by urinary excretion in rats. The data show that local wounding, local irradiation, or immediate local irradiation of a wound does not alter the rate of urinary excretion of free or bound hydroxyproline or the quantity of free hydroxyproline excreted; and a dorsal wound or irradiation of the dorsal skin does not alter the quantity of bound hydroxyproline excreted, but immediate local irradiation of a dorsal wound significantly depresses the quantity of bound hydroxyproline excreted in the urine. It was concluded that the wound milieu immediately sensitizes the resident fibroblasts to irradiation exposure. (C.H.)

**16961** CIRCULATION OF PEDICLE FLAPS STUDIED BY TISSUE CLEARANCE OF /sup 99m/Tc-PERTECHNETATE. Schnur, Paul; Simons, John N.; Tauxe, W. Newlon (Mayo Clinic, Rochester, Minn. Univ. of Minnesota, Rochester). Surg. Forum; 20: 513-14(1969).

From 55th Annual Clinical Congress, San Francisco, Calif. See CONF-691028-(Absts.).

Recent reports suggest that neocirculation can support pedicle skin grafts in less than the usual attachment time of three weeks. A method of evaluating pedicle skin flap neocirculation with freely diffusible radioactive tracers was tested experimentally in dogs and clinically to evaluate the minimal time period before transection and between transfers. Repeated injections of $^{99m}Tc$ at the same site under identical environmental conditions showed excellent reproducibility in clearance rates. (C.H.)

**16962** THE EFFECT OF EDTA ON THE PREFERENTIAL INTESTINAL ABSORPTION OF ZINC AND MANGANESE IN TURKEY POULTS. Vohra, Pran; Gonzales, Nestor (Univ. of California, Davis). Poultry Sci.; 48: 1509-10(Jul 1969).

The effect of EDTA on the simultaneous absorption of $^{65}Zn$ and $^{54}Mn$ was investigated in turkey poults raised to an age of about 28 days on 4 purified diets containing 25% casein and 8% gelatin as the sources of protein, 46% starch and the necessary mineral and vitamin supplements. The $^{65}Zn$ and EDTA-$^{14}C$ are not absorbed at the same rate in chickens from a $^{65}Zn$-EDTA-$^{14}C$ complex, but, in contrast to $^{65}Zn$, the intestinal absorption of $^{54}Mn$ was not increased significantly by EDTA in chickens. An aqueous solution of carrier-free $^{65}ZnCl_2$ and $^{54}MnCl_2$ in 1% NaCl was prepared and the ratio of $^{65}Zn/^{54}Mn$ was determined in this solution by the use of a 2-channel $\gamma$ spectrometer. About 2.5 ml of this solution was introduced into the isolated intestinal segments of the poults for absorption studies and the poults were kept alive under anaesthesia for 2 hr before withdrawing blood by a heart puncture. Intestinal segments were removed for determination of the residual $^{65}Zn$ and $^{54}Mn$ radioactivity. The ratio of $^{65}Zn/^{54}Mn$ in the original solution was 2.24 but decreased to 1.63 in poults fed the Zn-deficient diet, indicating a preferential absorption of $^{65}Zn$ over $^{54}Mn$ through the intestinal segment. This was further confirmed by a very high ratio of the isotopes in the blood (4.63). With the supplementation of this diet with Zn, the isotopic ratio in the isolated segment was slightly increased, indicating that $^{65}Zn$ absorption was slightly reduced in comparison to that of $^{54}Mn$. This was further reflected in a reduction in the isotopic ratio to 1.68 in the blood indicating a greater absorption of $^{54}Mn$ than of $^{65}Zn$. When EDTA was added to the Zn-deficient or Zn-supplemented diets, it enhanced the absorption of $^{65}Zn$ from the intestinal segment to the blood, as is indicated by the isotopic ratios of 1.19 and 1.52 in the respective segments; and 5.59 and 2.52 in the corresponding blood samples. The results indicate that EDTA stimulates preferentially the absorption of Zn over Mn when both elements are present simultaneously in the intestinal tract of the poults. (BBB)

**16963** WHOLE-BODY COUNTER STUDIES ON THE ABSORPTION OF $^{60}Co$, $^{59}Fe$, $^{54}Mn$, AND $^{65}Zn$ BY CHICKS, AS AFFECTED BY THEIR DIETARY LEVELS AND OTHER SUPPLEMENTAL DIVALENT ELEMENTS. Suso, F. A.; Edwards, H. M. Jr. (Univ. of Georgia, Athens). Poultry Sci.; 48: 933-8(May 1969).

Five experiments were conducted to study the effects of various dietary levels of Co, Fe, Mn, and Zn as well as other elements on the absorption of $^{60}Co$, $^{59}Fe$, $^{54}Mn$, and $^{65}Zn$ by chickens (2-week-old Single Comb White Leghorn males). Feeding high levels of the stable elements resulted, in general, in lower absorption and reduced biological half-life of their isotopes, possibly due to a faster metabolism of the elements in the body or to specific homeostatic control for the amounts of each element present in the body. An interaction between Zn and Cd or Hg was clearly shown, as evidenced by the decrease of $^{65}Zn$ absorption and the increase of zero-day retention values. Iron, also, depressed the absorption and increased the retention at zero-days of $^{65}Zn$, and Zn increased $^{59}Fe$ absorption, indicating some type of relation between these elements. The increase in the absorption of $^{59}Fe$ and $^{60}Co$ when high levels of Ni were added to the diet, were not statistically significant. (BBB)

**16964** TOXICITY OF HIGH LEVELS OF $^{65}Zn$ TO AVIAN EMBRYOS. Mraz, Frank R. (Univ. of Tennessee, Oak Ridge). Contract AT(40-1)-GEN-242. Poultry Sci.; 48: 1460-2(Jul 1969).

The uptake of $^{65}Zn$ by the chick embryo and mortality at different periods of incubation are reported. Fertile White Leghorn eggs were aseptically injected with $^{65}Zn$ in the chloride form. In the first experiment, 5 $\mu$Ci $^{65}Zn$ (0.01 mg Zn) was injected into 68 eggs at 3 days of incubation. In the second experiment, 5 levels of $^{65}Zn$ (50, 100, 200, 400, or 800 $\mu$Ci with 0.1, 0.2, 0.4, 0.8, or 1.6 mg Zn, respectively) were injected into eggs at 4, 8, or 14 days of incubation. From 9 to 35% of the $^{65}Zn$ was found in the shell and shell membranes. Embryos usually died shortly after injection of 400 $\mu$Ci or more of $^{65}Zn$. Survival of the embryos was highest when the injection occurred at 14 days of incubation. Even the 50-$\mu$Ci level appeared to be toxic to some extent. Since it took at least 400 $\mu$Ci of $^{65}Zn$ to ensure 100% mortality of the embryo and the peak uptake by the egg was 3.23% of the hen's dose that occurred at the 6th day after intramuscular administration, it would theoretically require a single dose of over 12 mCi in the hen to produce this level. No gross abnormalities usually associated with irradiation were observed, due primarily to the rapid death. (BBB)

**16965** ACCUMULATION OF $^{54}Mn$, $^{60}Co$, AND $^{185}W$ IN THE ROE OF THE BLACK SEA FLOUNDER. Ivanov, V. I. (Inst. of Biology of the Southern Seas, Sevastopol). Gidrobiol. Zh., Akad. Nauk Ukr. SSR; 5: No. 2, 58-9(1969). (In Russian).

Incorporation of radioactive isotopes into the roe of Scophthalmus maeoticus maeoticus (Pallas) from solutions containing $10^{-6}$ Ci/l to $10^{-5}$ Ci/l $^{54}Mn$, $^{60}Co$, and $^{185}W$ at 17°C to 19°C was studied. Coefficients of incorporation at 6 hr, 12 hr, 1 day, 2 days, and 3 days were, respectively, for $^{54}Mn$: 0.053, 0.11, 0.40, 1.6, 3.3; for $^{60}Co$: 1.5, 2.28, -3.06, 4.94; for $^{185}W$: 2.15, -, 5.45, -, 9.45; errors reported as standard deviations were 7% to 20%, averaging mostly at 12%. The nature of incorporation of Mn and W is similar to that of $^{91}Y$, $^{144}Ce$, and $^{106}Ru$. The accumulation is expected to be dependent on the chemical form and physicochemical state of the radioisotopes in the Black Sea; data here were for $MnCl_2$, $CoCl_2$ and Na tungstate. (BBB)

**16966** UPTAKE AND DISTRIBUTION OF $^{86}Rb$ AND $^{43}K$ IN MICE AND RATS: AN AUTORADIOGRAPHIC STUDY. Olsson, Kurt A.; Soeremark, Rune; Wing, Kenneth R. (Umea Univ. Dental School, Sweden). Acta Physiol. Scand.; 77: 322-32(Nov 1969).

The uptake and distribution in mice of $^{86}Rb$ and $^{43}K$ were studied using whole-body autoradiographic techniques. In addition, a microautoradiographic study of the distribution of $^{86}Rb$ in the heads of rats was made. The results demonstrate the high relative accumulation of $^{86}Rb$ in hyaline and articular cartilage, tendon, forming bone, liver, pancreas, salivary glands, thymus, spleen, and skeletal muscle. At 1 hr postinjection, the distribution pattern of $^{43}K$ was similar to but much less differentiated than that of $^{86}Rb$. Relative to the accumulation of each in skeletal muscle, $^{86}Rb$ was more concentrated than $^{43}K$ in hyaline and articular cartilage, tendon, and liver, while the converse was seen in heart, muscle, lung, bone, and brain. The micro-autoradiograms demonstrated high relative uptake of $^{86}Rb$ in trabecular bone and the dentin and enamel of unerupted teeth. The results were compared to those of previous quantitative studies on the accumulation of $^{86}Rb$ and $^{42}K$, and found to be in close agreement. Similarities to and differences from the results of a similar study of the uptake and distribution of $^{137}Cs$ are discussed. (auth) (BBB)

**16967** METABOLISM OF RADIOIODIDE BY LACTATING GOATS GIVEN $^{131}I$ FOR EXTENDED PERIODS. Lengemann, F. W. (Cornell Univ., Ithaca, N. Y.). Contract AT(30-1)-2147. J. Dairy Sci.; 53: 165-70(Feb 1970).

Twenty-two goats were given twice-daily doses of $^{131}I$ to determine distribution of radioiodine into milk, urine, feces, and thyroids as these animals approached steady state. For 16 goats on the control diet, 36.7 and 5.6% of a daily dose of $^{131}I$ per liter was found in the milk and plasma, respectively. The $^{131}I$ milk-plasma ratio was 7.6. Supplementing the control diet with 4 mg of iodine

per day resulted in a reduction of thyroid $^{131}I$ and an increase in $^{131}I$ in milk, whereas 1.2 g of KI per day markedly reduced the $^{131}I$ in milk and reduced the M/P ratio by a factor of 10. Perchlorate, fluoroborate, thiourea, Chlorothiazid, and thyroxine reduced the iodine concentration in milk. Though the ability of the goat to concentrate iodide in milk is greater than for the cow, the mechanisms of concentration appear to be similar. (auth)

## Radiation Effects

*Refer also to abstracts 16935, 17019, 17037, 17132, 17146, 17172, 17173, 17184, 17185, and 17187.*

**16968** (COO-2012-4) BIOCHEMICAL STUDIES ON THE OCULAR LENS IN RELATION TO CATARACTOGENESIS. Progress Report No. 4, December 1, 1968-January 31, 1970. Kinsey, V. Everett; Reddy, V. N. (Oakland Univ., Rochester, Mich. Inst. of Biological Sciences). Contract AT(11-1)-2012. 14p. Dep. CFSTI.

The onset of cataracts following exposure to ionizing radiation is accompanied by a fall in the concentration of glutathione (GSH). In view of this, a $^{14}C$ tracer study was designed to determine whether variations in the permeability of the lens surface membrane were responsible for the phenomenon. Barring the existence of an extended latent period, which is currently under study, it was found that x irradiation did not alter the permeability of the lens membrane to GSH. Research is also continuing in the investigation of the source of the potential difference that exists between the inside and the outside of the lens. Results of experiments involving the movement of chlorides across the membrane strongly suggest that sodium is actively transported across the membrane and that this is responsible for the current. It was further concluded that the negative lens fiber potential results from the action of this sodium pump. Studies of the kinetics of the pump-leak system of transport in the ocular lens are being continued by considering the separate effects of the electric and chemical potentials on ion flux. The mathematical theory for determining this has been worked out and is now being applied to the movement of K, Rb, and Cs. Solution of the simultaneous equations involved requires an analog computer using a method of successive approximation. Studies on the kinetics of amino acid transport in the lens were continued using taurine transport as the model system. It was found that the kinetics involved do not conform to Michaelis-Menten kinetics. Observed increases in the velocity of transport with increased substrate concentration suggest substrate inhibition; several enzyme systems exhibiting similar kinetics also demonstrate this phenomenon. The inhibiting effect of ouabain on taurine transport, and the effect of K depletion on taurine accumulation, suggest that the taurine transport system may be directly linked to sodium-potassium ATPase. Investigation of the role of ciliary processes in ion movement and the satisfaction of metabolic needs is complete and the results are currently being published. These results, in keeping with current views, are concerned primarily with the formation of the posterior aqueous and how substances are eliminated from this fluid and the vitreous humor. (E.R.B.)

**16969** (NYO-3461-3, Paper 2) RADIATION EFFECT ON CLAM THIAMINASE ACTIVITY AS MEASURED BY AN IMPROVED ASSAY METHOD. Liu, May Chih-mei (Massachusetts Univ., Amherst. Dept. of Food and Nutrition). 37p.

Thesis.

The Gnaedinger method for determining the activity of thiaminase in fish was modified in serveral ways in order to increase the precision of the measurement of thiaminase activity. A new method was devised for measuring the 0 time instantaneous rate of thiamine destruction by reaction with thiaminase for not more than 10 minutes. Exponential curves were fitted by a least-square method to thiochrome fluorescence readings corresponding to thiamine remaining after reaction with clam thiaminase. Clam thiaminase activity was expressed as micrograms of thiamine destroyed per minute at 0 time per gram of clam solids. The activity of thiaminase in nonradiated clams and that in clams $^{60}Co$ $\gamma$-radiated at the 0.8 megarad level were found to be equal to 13.4 and 6.1 mcg of thiamine destroyed at 0 time per minute per g of clam solids, respectively. (auth)

**16970** EFFECT OF IONIZING RADIATION ON NUCLEAR CELL PROTEINS: CHANGES IN SH-GROUP CONTENT IN PROTEINS SYNTHESIZED IN LATE INTERPHASE. Kedrova, E. M.; Rodionov, W. M. (Inst. of Biological and Medical Chemistry, Moscow). Int. J. Radiat. Biol.; 16: 359-66(1969).

Changes in the content of thiol groups are observed in proteins of the globulin fraction extracted with 0.14 M NaCl solution from the nuclei of intact and regenerating rat liver cells after x-irradiation (1500 R). Nuclear globulins were subdivided into RNP, water-soluble and salt-soluble proteins. The SH-group amount in all these proteins increased 28.5 hours after partial hepatectomy. Immediately after irradiation the SH-group content in the RNP and salt-soluble proteins decreased. In the RNP the amount of SH-groups was restored up to the initial level an hour after irradiation. For salt-soluble proteins, no repair of the SH-group content was revealed. The time of nuclear globulin synthesis in regenerating rat-liver cells was also studied. The content of salt-soluble proteins in the nuclei of regenerating rat-liver cells increase at 28 hours after partial hepatectomy, i.e., in the period of the maximum of the mitotic activity. The incorporation rate of glycine-$^{14}C$ in salt-soluble proteins had a maximum 27 hours after partial hepatectomy. The maximum incorporation of the label into the other fractions was observed 25 hours after partial hepatectomy. It is suggested that salt-soluble proteins are part of the proteins of the mitotic apparatus and that the anti-mitotic effect of ionizing radiations is related to inactivation of the SH-groups of these proteins. (auth) (UK)

**16971** RADIATION-INDUCED INACTIVATION OF LYSOZYME. Aldrich, J. E.; Cundall, R. B. (Univ. of Nottingham, Eng.). Int. J. Radiat. Biol.; 16: 343-58(1969).

Lysozyme was irradiated in dilute aqueous solutions with $^{60}Co$ $\gamma$-rays. Variation of pH, the presence or absence of oxygen and nitrous oxide and other additives has made it possible to investigate the separate roles of hydroxyl radicals, solvated electrons, and hydrogen atoms as inactivating species. Hydrogen atoms inactivate the enzyme with an effectiveness that increases at low pH values; electrons are not particularly effective. The hydroxyl radical is the species responsible for about 90% of the inactivation at intermediate pH. Inactivation measurements on solutions irradiated at different pH values show that the sensitivity to inactivation by hydroxyl radicals and hydrogen atoms depends on the configuration of the protein. The mechanism of the reaction with the hydroxyl radical in the presence and absence of oxygen has been studied by uv-absorption changes and probably involves oxindolylalamine or kynurenine structures. Changes in aggregation and molecular conformation have been investigated by gel filtration and optical rotatory dispersion. The evidence suggests that reaction of the hydroxyl radical with tryptophan residues is largely responsible for the radiation-induced inactivation. (auth) (UK)

**16972** MECHANISM OF THE RADIATION-INDUCED INACTIVATION OF LYSOZYME IN DILUTE AQUEOUS SOLUTION. Adams, G. E. (Mount Vernon Hospital, Northwood, Eng.); Willson, R. L.; Aldrich, J. E.; Cundall, R. B. Int. J. Radiat. Biol.; 16: 333-42(1969).

Combined pulse-radiolysis and enzyme-activity studies have shown that the radiation-induced inactivation of lysozyme in neutral aqueous solution is due principally to the reaction of hydroxyl radicals with tryptophan residues. Unlike some typical OH-radical scavengers which protect against inactivation, the thiocyanate ion $(CNS)_2^-$ does not. This is due to a specific reaction between the thiocyanate radical and tryptophan residues. Part of this inactivating process involves tryptophan at position 108. (auth) (UK)

**16973** MECHANISM OF INHIBITION OF THE ADAPTIVE SYNTHESIS OF TRYPTOPHAN PYRROLASE IN THE RAT LIVER DURING $\gamma$ IRRADIATION. Mel'nikova, S. K.; Kuzin, A. M. (Inst. of Biological Physics, Pushchino, USSR). Radiobiologiya; 9: 806-10(Nov-Dec 1969). (In Russian).

To determine the mechanisms of the radiation inhibition of the adaptive synthesis of tryptophan pyrrolase, the induction of the enzyme in normal and irradiated animals under the influence of RNA preparation isolated from normal and induced organism, as well as the influence of actinomycin D and adrenalectomy on these processes were studied. On the basis of the data obtained, it was concluded that part of the substrate induction of tryptophan pyrrolase was due to a DNA-dependent RNA synthesis that is inhibited during the first 24 hrs after irradiation at a dose of 1000 R. (tr-auth)

**16974** METABOLISM OF THYROID TISSUE AND THYROXIN METABOLISM DURING A RADIATION INFLUENCE. Tkachev, A. V. (Inst. of Medical Radiology, Obninsk, USSR). Radiobiologiya; 9: 811-15(Nov-Dec 1969). (In Russian).

In acute radiation sickness, a decrease in the sensitivity of the thyroid gland to exogenous thyroid-stimulating hormone 24 hr after irradiation and an intensification three days after irradiation were observed. After irradiation at a dose of 900 R there was a retention of $^{131}I$-thyroxin in the muscles, but its elimination from the liver was accelerated. The quantitative content of $^{131}I$-thyroxin in the liver, kidneys, blood, adrenals, and other organs did not differ significantly in the control and irradiated rats over a period of 72 hr after administration. (tr-auth)

**16975** CONFORMATION OF UV-IRRADIATED DNA. Bagchi, B.; Basu, S.; Misra, D. N.; Das Gupta, N. N. (Saha Inst., Calcutta). Int. J. Radiat. Biol.; 16: 301-10(1969).

The effects of uv on DNA have been found to be manifold. The initial effect characterized by a fall in absorbance, rise in sedimentation coefficient and appearance of kinks in many places of the molecule has been attributed to dimerization of the pyrimidines and formation of single-strand breaks. Together with the occurrence of kinks the molecule becomes folded up and assumes a ring-like appearance at several places; this is partly due to intramolecular cross-links. With an increase in dose a third effect, i.e., double-strand break which results in backbone scission, comes into play and predominates. This effect is manifested in a further decrease in absorbance, a fall in sedimentation constant, and the appearance of shorter molecules in the electron microscope. At still higher doses, an equilibrium state is reached when both absorbance and sedimentation coefficient remain steady. The resulting molecules were so short that the effect of dimer formation with the increase in dose was negligible. (auth) (UK)

**16976** COMPARISON OF THE EFFECTS OF ETHYLENIMINE AND IONIZING RADIATION ON THE SUPERMOLECULAR STRUCTURE OF LOACH SPERM DNA AND THE SURVIVAL RATE OF THE EMBRYOS AFTER FERTILIZATION OF IRRADIATED OR ETHYLENIMINE-TREATED SPERM. Vinogradova, I. D.; Shekhtman, Ya. L. (Inst. of Biological Physics, Pushchino, USSR). Radiobiologiya; 9: 795-800(Nov-Dec 1969). (In Russian).

The effects of ethylenimine and ionizing radiation on the damage to loach sperm cells and the elastoviscosity of the DNA of these cells were compared. A parallelism in the action of low doses of the mutagen and radiation, both with respect to death of the roe fertilized with treated sperm, at the stage of cleavage, and with respect to the decrease in the elastoviscosity of DNA isolated from the irradiated or ethylenimine-treated sperm was studied. (tr-auth)

**16977** DISTRIBUTION OF MAGNESIUM IN THE ORGANELLES OF THE RAT THYMUS IN THE NORMAL STATE AND IN THE EARLY PERIODS AFTER THE INFLUENCE OF IONIZING RADIATION. Gorizontova, M. P.; Ezhova, V. M.; Zhulanova, Z. I.; Romantsev, E. F. (Inst. of Normal and Pathological Physiology, Moscow. Inst. of Biophysics, Moscow). Radiobiologiya; 9: 832-5(Nov-Dec 1969). (In Russian).

The Mg content in the nuclei, mitochondria, and supernatant liquid of the rat thymus was studied in the normal state and in the early periods after whole-body irradiation at a dose of 1000 R. An increase in the Mg content in thymus nuclei 3 min, 1, and 24 hrs after irradiation was observed. In the mitochondria and thymus of irradiated rats, it was practically unchanged. (tr-auth)

**16978** CHANGE IN THE ADRENOCORTICOTROPIC FUNCTION OF THE ADENOHYPOPHYSIS IN THE LONG-TERM PERIODS AFTER IRRADIATION. Prokudina, E. A. (Central Roentgenoradiological Scientific Research Inst., Leningrad). Radiobiologiya; 9: 820-3(Nov-Dec 1969). (In Russian).

In the long-term periods after a single whole-body irradiation of rats, the adrenocorticotropic function of the anterior lobe of the pituitary is changed. The impairment of function is expressed as an inhibition of the secretion and accumulation of ACTH in the pituitaries of irradiated animals. The inhibition of the secretory ACTH function of the pituitary is apparently based on a disturbance of the process of its regulation, since the use of adrenalin produces a total mobilization of ACTH from the pituitaries of the irradiated animals. (tr-auth)

**16979** ANALYSIS OF THE ROLE OF THROMBOCYTOPOIETINS IN THE REGULATION OF THROMBOCYTOPOIESIS OF IRRADIATED ANIMALS. Traskunova, N. V. (Central Roentgenoradiological Scientific Research Inst., Leningrad). Radiobiologiya; 9: 824-8(Nov-Dec 1969). (In Russian).

It was shown that the use of exogenous thrombocytopoietins (ET) permitted a stimulation of thrombocytopoiesis of irradiated animals. The influence of ET on the irradiated organism seven days before radiation damage reduced the degree of expression of thrombocytopenia in the period of the greatest inhibition of thrombocytopoiesis. The use of ET in the period of restoration of thrombocytopoiesis led to an earlier and more pronounced increase in the number of thrombocytes of the blood. Different sensitivities of the bone marrow of the irradiated organism to endogenous stimulators of thrombocytopoiesis and ET are noted. (tr-auth)

**16980** INFLUENCE OF IONIZING RADIATION ON THE CONTENT OF RADIOACTIVE $^{42}K$ IN CERTAIN ORGANS OF MICE. Vasil'ev, A. V.; Burlakova, E. V.; Burdin, K. S. (Moscow State Univ.). Radiobiologiya; 9: 927-9(Nov-Dec 1969). (In Russian).

The kinetics of the distribution of radioactive $^{42}K$ in the liver, muscles, and brain of nonirradiated and irradiated animals was studied in experiments on mice by the radioactive tracer method. Of the investigated organs of nonirradiated animals, $^{42}K$ is most rapidly accumulated in muscle tissues, and most slowly in the brain. Irradiation of the animals at the absolutely lethal dose (10,000 R) produces a sharp decrease in the $^{42}K$ content in all the investigated organs. The greatest yield of $^{42}K$ is observed in the first 2.5 to 3 hrs after x-irradiation of the animals. (tr-auth)

**16981** INVESTIGATION OF THE EARLY POSTRADIATION RESPONSE OF CELLS TO IRRADIATION. Burdin, K. S.; Petrusevich, Yu. M. (Moscow State Univ.). Radiobiologiya; 9: 931-3(Nov-Dec 1969). (In Russian).

Using the method of ultraweak chemiluminescence and the discharge of $K^+$ from the cells, we studied the generality of the processes observed during the early postradiation period. Gamma irradiation of cells in vitro at various doses produces intensive chemiluminescence and discharge of $K^+$ 1 to 2 hrs after irradiation. (tr-auth)

**16982** INFLUENCE OF IONIZING RADIATION ON PEXIA OF SEROTONIN AND ACETYLCHOLINE BY BLOOD AND TISSUES. Krichevskaya, E. I.; Rapoport, S. Ya.; Kapitonova, G. V. (Inst. of Higher Nervous Activity and Neurophysiology, Moscow). Radiobiologiya; 9: 917-20(Nov-Dec 1969). (In Russian).

It was established that tissues of various rat organs possess serotonino- and acetylcholinopexic activities. Irradiation at a dose of 800 R reduces the ability of the tissues to bind serotonin and acetylcholine. The pexic ability of the blood is changed under the influence of ionizing radiation only with respect to serotonin. The suppression of serotoninopexia for liver and stomach tissue is already detected after 5 min; for the tissues of the remaining organs investigated, distinct changes are observed after 2 hrs. Acetylcholinopexia of the tissues of all the investigated organs is reduced 5 min after irradiation. (tr-auth)

**16983** STUDY OF RNA BIOSYNTHESIS IN LIVER NUCLEI OF IRRADIATED RATS. Pashkevich, I. F.; Todorov, I. N. (Scientific Research Inst. of Medical Radiology, Kharkov. Inst. of Radiophysics and Electronics, Kharkov). Radiobiologiya; 9: 901-3 (Nov-Dec 1969). (In Russian).

RNA biosynthesis in liver nuclei of normal and irradiated rats (2 and 24 hrs after irradiation at a dose of 800 R) in the presence of actinomycin D, calf thymus histones, trypsin, and DNAase was studied. It was shown that radiation increased the inhibitory effects of histones and actinomycin D on RNA synthesis and decreased the stimulating effect of trypsin. As a result of irradiation the percentage of undecomposed DNA in the nuclei after incubation with DNAase is significantly increased, whereas the rate of RNA synthesis is practically unchanged. (tr-auth)

**16984** DISTURBANCE OF THE STATE OF THE DNA-PROTEIN COMPLEX OF CHROMATIN IN THE CELL NUCLEUS UNDER THE INFLUENCE OF IONIZING RADIATION. Strazhevskaya, N. B.; Troyanovskaya, M. L.; Struchkov, V. A.; Krasichkova, Z. I. (Inst. of Biological Physics, Pushchino, USSR). Radiobiologiya; 9: 903-5(Nov-Dec 1969). (In Russian).

A sensitive method, permitting an investigation of the state of the DNA-protein complex of the chromatin of the cell nucleus after irradiation at biological doses, is proposed. It was shown that 100 R in experiments in vitro and 1000 R in vivo produce significant changes in the state of the DNA-protein complex of the chromatin immediately after irradiation. (tr-auth)

**16985** COUPLED OXIDATIVE PHOSPHORYLATION IN THE NORMAL STATE AND AFTER IRRADIATION OF GERMINATING SEEDS FROM VARIOUS ECOLOGICAL SITES OF COTTON CULTIVATION. Arslanova, S. V.; Kasymov, A. K.; Egamberdyeva, A. M. (Inst. of Experimental Plant Biology, Tashkent). Radiobiologiya; 9: 905-8(Nov-Dec 1969). (In Russian).

In the irradiation of germinating cotton seeds from different sites of cultivation, the intensity of oxygen absorption increases. The binding of inorganic phosphorus is suppressed. The degree of disturbance of processes of oxidative phosphorylation is lower in plants of high altitude areas in comparison with the plants of the valley. Cultivating seeds of high altitude plants for three generations in Tashkent reduced this difference. The total content of quinones in the leaves of nonirradiated plants is greater among the high mountain plants than in the lowland plants. (tr-auth)

**16986** FRACTIONATION OF HEMOGLOBIN OF IRRADIATED ANIMALS BY THE METHOD OF DISC ELECTROPHORESIS. Starodub, N. F. (Inst. of Physiology, Kiev). Radiobiologiya; 9: 909-11(Nov-Dec 1969). (In Russian).

The heterogeneity of rat hemoglobin before and after irradiation with x rays and fast neutrons in biologically equivalent absolutely lethal doses was studied in the work. It was established that the

hemoglobin of nonirradiated animals is separated into five distinct fractions by the method of disc electrophoresis. Irradiation produces substantial disturbances of the fractional composition of hemoglobin, expressed both in a change in their quantitative ratio and in the appearance of new fractions. Fast neutrons produce a more profound disturbance in comparison with x rays. (tr-auth)

**16987** GLUCOSE-6-PHOSPHATE DEHYDROGENASE ACTIVITY IN THE MUCOUS MEMBRANE OF VARIOUS PORTIONS OF THE RAT SMALL INTESTINE AFTER RADIATION SICKNESS. Korzhov, V. I. (Kiev Roentgenoradiological and Oncological Scientific Research Inst.). Radiobiologiya; 9: 911-13(Nov-Dec 1969). (In Russian).

It was shown that the activity of glucose 6-phosphate dehydrogenase (G-6-PDH) in the mucous membrane of various portions of the rat small intestine is increased 12 hrs, 8, 14, 21, and 28 days after total irradiation of rats at a dose of 800 R. (tr-auth)

**16988** ELECTROPHORETIC BEHAVIOUR OF CERTAIN ENZYMATIC PROTEINS (LDH, GOT, LAP, G6PD) OF LIVER AND HEART OF ALBINO RATS PAN-IRRADIATED WITH ROENTGEN RAYS USING VARIOUS MODALITIES. Notario, A.; Bobbio Pallavicini, E.; Rodolico, R.; Marciano, S. (Univ. of Pavia, Italy). Minerva Radiol.; 14: 443-53(Oct 1969). (In Italian).

The electrophoretic behaviour of the isoenzymes LDH, GOT, LAP, and G6PD obtained from the liver and myocardium of rats pan-irradiated with Roentgen rays either with a single lethal dose or a single non-lethal dose repeated for variable periods of time, was studied. Shifts in the percentage values of the different isoenzymes were observed. These generally involved an increase in those fractions with more rapid anodic migration. This increase was more or less evident depending on what enzymatic activity was under study and on the organ at which the enzyme originated. In no case were there abnormalities in the tracings, even with the most intense treatments. (auth)

**16989** ON THE RADIATION-INDUCED REACTION OF IODOACETAMIDE WITH ALBUMIN AND WITH THE ERYTHROCYTE MEMBRANE. Myers, D. K.; Tribe, T. A.; Mortimer, R. (Atomic Energy of Canada Ltd., Chalk River, Ont.). Radiat. Res.; 40: 580-7(Dec 1969).

Irradiation of intact erythrocytes in the presence of iodoacetamide (IAm) induces a binding of acetamide moiety to the cell membrane. This reaction does not alter the mechanical strength of the membrane but does render it more susceptible to lysis by the phospholipases of snake venom. Most of the acetamide moiety attached to the membrane during irradiation appears to be associated with the protein fraction rather than the lipids, even though unsaturated fatty acids in solution react very effectively with IAm during irradiation. Experiments with albumin indicated that several amino acids are involved in the radiation-induced reaction between IAm and protein. (auth)

**16990** DNA VARIATION IN THE LIVER OF IRRADIATED AND PARTLY HEPATECTOMIZED RATS. Izvoranu, M. Stud. Cercet. Biol., Ser. Zool.; 20: 417-20(1968). (In Rumanian).

The quantitative variations of DNA were studied in a partly hepatectomized liver, following the total irradiation of rats with a lethal dose of 1000 R x radiation. One group of test animals was exposed during three successive stages, and another one was delivered a single dose of 1000 R at one time. The findings revealed that in irradiated animals hepatectomy activated DNA synthesis. The biochemical regeneration of radioactive lesions in the latter group was slower than in the former one. (auth) (Rom. Sci. Abstr.)

**16991** EXCITATION OF TRYPTOPHAN IN SOLUTION DURING IRRADIATION WITH X-RAYS AND UV LIGHT BETWEEN 77°K AND 300°K. Steen, H. B. (Norwegian Radium Hospital, Montebello, Oslo). Radiat. Res.; 41: 268-87(Feb 1970).

The temperature dependence of the yields of the x-radioinduced fluorescence and phosphorescence of tryptophan in ethylene glycol-water solution, between 77 and 300°K, was found to be quite different from that observed upon excitation with nonionizing uv light. Thus, while the quantum yields of the fluorescence and phosphorescence, induced by 270-nm uv light, were independent of the temperature up to about 220 and 140°K, respectively, the yields of the x-radioinduced emissions decreased by more than a factor of two within the same ranges of temperature. For both types of irradiation, the phosphorescence-to-fluorescence ratio remained constant up to 140°K, being 3.6 for x rays and 0.46 for uv light. However, the marked drop in this ratio observed, in both cases, around 160°K was much more pronounced for x irradiation. The temperature dependence of the phosphorescence decay time was identical for the two types of irradiation. The difference between the results obtained with x rays and uv light was attributed primarily to ion recombination. Thus, it was calculated that about 85% of the x-radioinduced luminescence at 77°K was due to this process, the remainder resulting from excitation directly from the ground state. The significance of ion recombination decreased markedly above 140°K and became negligible above 220°K. It was calculated that for x irradiation, below 140°K, about 75% of the excitation by ion recombination was to the triplet manifold, while the corresponding percentage for excitation directly from the ground state was limited upwards to 35%. (auth)

**16992** MODIFICATION OF POST-IRRADIATION DNA DEGRADATION IN ESCHERICHIA COLI B/r. Cramp, W. A.; Watkins, D. K. (Hammersmith Hospital, London). Radiat. Res.; 41: 312-25(Feb 1970).

Thymine $^{14}C$ labeled Escherichia coli B/r were irradiated with electrons in saline (M/15) in the presence of, or after treatment with, solutions of various compounds that either enhanced or diminished the effects of radiation on cell survival. Loss of radioactivity from the acid-precipitable DNA was used as a measure of DNA breakdown. Thiourea, glycerol, dimethyl sulfoxide, N-ethyl maleimide, indanotrione, and acriflavine were used at the optimum concentrations for protection or sensitization (cell survival). Two of the protective agents, thiourea (0.3 M) and dimethyl sulfoxide (1.0 M), almost completely inhibited post-irradiation breakdown when bacteria were irradiated in their presence, while the third, glycerol (1.0 M), had little or no effect. Of the three sensitizing agents, indane trione ($8 \times 10^{-4}$ M) and acriflavine ($2 \times 10^{-5}$ M) completely inhibited degradation, but N-ethyl maleimide ($5 \times 10^{-4}$ M) had only a slight inhibitory effect. When bacteria were exposed to these compounds before irradiation and then washed, both indantrione and acriflavine still inhibited DNA degradation. None of these six compounds affected cell survival after preirradiation washing. It was concluded that for this strain of bacteria, DNA degradation could be inhibited while the colony forming ability remained the same or was greater or less than in cells in which DNA degradation was not inhibited. (auth)

**16993** RELATIVE STABILITY OF THE CHARACTERISTIC SULFUR AND DOUBLET RESONANCES IN X-IRRADIATED NATIVE PROTEINS AS MEASURED WITH ESR. Shields, Howard; Hamrick, Phillip J. Jr. (Wake Forest Univ., Winston-Salem, N. C.). Radiat. Res.; 41: 259-67(Feb 1970).

Electron spin resonance (ESR) measurements of the relative stability of the superimposed doublet and sulfur resonances in some x-irradiated native proteins show that the doublet resonance is less stable than the sulfur resonance. First-order kinetics give an activation energy of 0.3 eV for the decay of the doublet resonance. The decay of the more stable sulfur resonance does not follow a simple first-order decay law. (auth)

**16994** CREATINE PHOSPHOKINASE AND OTHER SERUM ENZYMES DURING RADIOTHERAPY. Muggia, Franco M.; Ghossein, Nemetallah, A.; Hanok, Albert (Yeshiva Univ., Bronx, N. Y.). J. Amer. Med. Ass.; 211: 1345-50(23 Feb 1970).

Twenty-one patients receiving irradiation to major portions of the heart and 24 patients receiving noncardiac irradiation had serial determinations of serum enzymes including lactic acid dehydrogenase (LDH), serum glutamic oxaloacetic transaminase (SGOT), serum glutamic pyruvic transaminase (SGPT), and creatine phosphokinase (CPK) before, during, and after therapy. The following conclusions were reached: the serum LDH and SGOT values are not useful to detect radioinduced myocardial damage since they (as well as the SGPT) are frequently abnormal and likely to reflect a variety of complications related to the neoplastic disease itself; the CPK remains normal in patients receiving irradiation to various tumors, including large areas of skeletal muscle and the right border of the heart, but excluding the major muscular portion of the heart; and a rise in CPK value, noted in five patients during and in two patients following irradiation to the heart, may reflect radioinduced myocardial damage. (auth)

**16995** PROTEOLYTIC DIGESTION RATES FOR ALTERED ENZYMES. Stevens, C. O.; Sauberlich, H. E. (Fitzsimons General Hospital, Denver). Radiat. Res.; 41: 362-74(Feb 1970).

Native and unfolded forms of ribonuclease, lysozyme, and trypsin were subjected to partial proteolysis with trypsin or pronase. Soluble peptides were formed from the mixed disulfides of lysozyme or ribonuclease, with cystine at a rate intermediate between the rates of soluble peptide formation from native and other unfolded forms of these two enzymes. Active and inactive products isolated from γ-irradiated lysozymes samples were subjected to limited proteolysis employing trypsin and to extensive proteolysis employing combined peptic-tryptic hydrolysis. Alterations in conformation or motility of peptide chains were detected in all products tested, including the one most nearly corresponding chromatographically to native lysozyme. Detection of alterations was dependent upon following more than one parameter of proteolysis.

A change in the rate or extent of peptide bond cleavage was not always accompanied by a change in rate of proteolytic release of trichloroacetic acid soluble peptides. Of the three proteases studied, the use of trypsin most consistently revealed differences between the protease substrates. The use of trypsin was indicated for the production of a limited number of large peptide intermediates from lysozyme derivatives for isolation and characterization to reveal small conformational changes. The use of a combination of pepsin and trypsin was indicated for the production of a mixture of small peptides containing disulfide bonds rearranged in lysozyme derivatives from their position in native lysozyme. (auth)

**16996** THE ACTION OF IONIZING RADIATION ON TRANSCRIPTION (AND TRANSLATION) IN SEVERAL STRAINS OF ESCHERICHIA COLI. Pollard, E. C.; Davis, Sharon A. (Pennsylvania State Univ., University Park). Contract AT(30-1)-2804. Radiat. Res.; 41: 375-99(Feb 1970).

The effect of $^{60}$Co $\gamma$ rays on transcription and translation in cells of Escherichia coli was studied. Two methods of observing transcription, the formation of RNA followed by pulse-labeling with $^{14}$C-uracil and the formation of three induced enzymes, were used. Nine strains were studied. Translation was followed by observing the effect of radiation on induced enzymes after induction. By observing $\beta$-galactosidase and transacetylase induction after irradiation, evidence for a polar effect in the lac operon was found. The results suggest wide strain variations in sensitivity and also wide variations in the induced enzymes. A bimodel sensitivity for the synthesis of RNA was found, suggesting that there are two ways in which RNA is synthesized. It was also found that operon-controlled messenger RNA synthesis is more sensitive to ionizing radiations and that after radiation the apparent messenger RNA half-life is increased. Suggestions for the mechanism of action in terms of the control processes are made. (auth)

**16997** STABLE MESSENGER RIBONUCLEIC ACID AND GERMINATION OF MYXOCOCCUS XANTHUS MICROCYSTS. Ramsey, W. Scott; Dworkin, Martin (Univ. of Minnesota, Minneapolis). J. Bacteriol.; 101: 531-40(Feb 1970).

Germination, protein synthesis, and ribonucleic acid (RNA) synthesis by microcysts of the fruiting myxobacterium Myxococcus xanthus were examined. The morphological aspects of microcyst formation were completed at about 2 hr after induction had begun. In such microcysts, germination, RNA synthesis, and protein synthesis were inhibited by actinomycin D (Act D). At 6 hr after induction, germination and protein synthesis had become relatively resistant to Act D, whereas RNA synthesis was inhibited by about 95%. Experiments with $^{3}$H-Act D indicated that the deoxyribonucleic acids of both young and old microcysts bind Act D equally. Resistance of germination to Act D was acquired 4 to 5 hr after induction of microcyst formation, and was due to an Act D-sensitive synthesis at that time. Vegative cells and microcysts were pulsed with uridine-5-$^{3}$H and chased for 60 min; the RNA was extracted and analyzed by means of sucrose density gradient centrifugation and gel electrophoresis. Both microcysts and vegetative cells contained grossly the same types of RNA in the same proportions. RNA pulse-labeled in microcysts was more stable than that in vegetative cells. No particular portions of the microcyst pulse-labeled RNA were selectively stabilized. These data indicate that a stable messenger RNA required for synthesis of germination proteins was synthesized during microcyst formation. This may be the same as the RNA synthesized 4 to 5 hr after initiation of microcyst formation. It is suggested that the existence of such stable messenger RNA in microcysts is consistent with the limited biosynthetic activities of such cells. (auth)

**16998** UREA-MERCAPTOETHANOL-SOLUBLE PROTEIN FROM SPORES OF BACILLUS THURINGIENSIS AND OTHER SPECIES. Somerville, H. J.; Delafield, F. P.; Rittenberg, S. C. (Univ. of California, Los Angeles). J. Bacteriol.; 101: 551-60 (Feb 1970).

Treatment with urea-mercaptoethanol of purified spores of Bacillus thuringiensis, other Bacillus species, and Clostridium roseum solubilizes a protein fraction between 5 and 12% of the dry weight of the spores. This fraction behaves identically to the crystal protein of B. thuringiensis on acrylamide-gel electrophoresis. The protein from all of the Bacillus species shows partial homology with crystal protein, using the Ouchterlony immunodiffusion technique. A further fraction, similar in amount, can be removed from spores of B. thuringiensis by the addition of sodium lauryl sulfate to the urea-mercaptoethanol. Spores of B. thuringiensis extracted in these ways show no difference when compared to untreated spores with respect to viability or resistance to heat and uv irradiation. The extracted spores do show differences in their germination requirements and their susceptibility to phase-darkening by lysozyme. It is concluded that an urea-mercaptoethanol-soluble protein or class of protein is a widespread component of bacterial spores, possibly located in the spore coat, and that this protein may be related to the crystal protein of B. thuringiensis. (auth)

**16999** ULTRAVIOLET-INDUCED DECREASE IN INTEGRATION OF HAEMOPHILUS INFLUENZAE TRANSFORMING DEOXYRIBONUCLEIC ACID IN SENSITIVE AND RESISTANT CELLS. Muhammed, Amir; Setlow, Jane K. (Oak Ridge National Lab., Tenn.). J. Bacteriol.; 101: 444-8(Feb 1970).

The decrease in integration of transforming deoxyribonucleic acid (DNA) caused by uv irradiation of the DNA was independent of the presence or absence of excision repair in the recipient cell. Much of the uv-induced inhibition of integration resulted from the presence in the transforming DNA of pyrimidine dimers, as judged by the photoreactivability of the inhibition with yeast photoreactivating enzyme. The inhibition of integration made only a small contribution to the inactivation of transforming ability of the DNA by uv radiation. (auth)

**17000** REPAIR OF ULTRAVIOLET-IRRADIATED TRANSFORMING DEOXYRIBONUCLEIC ACID IN HAEMOPHILUS INFLUENZAE. Beattie, Kenneth L.; Setlow, Jane K. (Oak Ridge National Lab., Tenn.). J. Bacteriol.; 101: 808-12(Mar 1970).

Ultraviolet-sensitive and wild-type Haemophilus influenzae cells were exposed to irradiated and unirradiated transforming deoxyribonucleic acid (DNA) containing a marker that can be linked to another marker in the cells. Lysates were made after various times of incubation and assayed for transforming activity on an excisionless recipient. Repair can be noted as an increase in activity from the irradiated donor DNA after its linkage to the recipient DNA. No repair can be observed in a mutant that is unable to integrate transforming DNA. There is a little repair in another mutant that is unable to excise pyrimidine dimers. H. influenzae cells also repair nondimer damage, as judged by the increase in activity observed in lysates made with irradiated and maximally photoreactivated DNA. (auth)

**17001** EFFECT OF GAMMA RADIATION ON PEROXIDASE DEVELOPMENT IN SWEET POTATO DISKS. Ogawa, Masami; Uritani, Ikuzo (Nagoya Univ., Japan). Radiat. Res.; 41: 35142-51 (Feb 1970).

Following irradiation with 90 krads of $^{60}$Co $\gamma$ radiation, roots of sweet potato were cut into thin disks and incubated aerobically at 30°C under high humidity. Gamma radiation significantly stimulated the peroxidase development during incubation of disks. The peroxidase development was strongly inhibited by low concentration of cycloheximide in the nonirradiated and irradiated disk tissues. Exposure to exogenous ethylene alone similarly stimulated the peroxidase development. Evidence indicated that the stimulation of peroxidase development by $\gamma$ radiation may be partly mediated through the enhanced amounts of ethylene produced in disks by $\gamma$ radiation, but it is mainly mediated by another unknown mechanism. Neither treatment by $\gamma$ radiation nor exogenous ethylene stimulated all components of peroxidase isoenzymes in a similar manner as appeared in response to cut injury, but did stimulate individual components among them. (auth)

## *Immunology*

*Refer also to abstracts 17070, 17126, and 17136.*

**17002** (AD-695424) EFFECT OF X IRRADIATION ON DELAYED HYPERSENSITIVITY AND CIRCULATING ANTIBODY. Bowser, R. T.; Spence, D. B.; Exum, E. D. (Armed Forces Radiobiology Research Inst., Bethesda, Md.). Oct 1969. 20p. (AFRRI-SR-69-17). CFSTI.

Rats exposed to x radiation 24 hours prior to antigen administration exhibited detectable skin reactions to tuberculin 2 days later than nonirradiated sensitized controls. Reaction sizes illustrate that the irradiated rat experienced a decreased sensitivity to tuberculin which persisted through day 14. The radiation dose (475 rads) responsible for the observed depression of the delayed skin reactions produced a greater depression of the circulating antibody response. The results obtained suggest that the cellular and humoral immune responses in the rat are radiosensitive. (auth) (TAB)

**17003** TRANSFORMATION OF MOUSE CELLS BY K-PAPOVAVIRUS. Takemoto, Kenneth K.; Fabisch, Phyllis (National Inst. of Allergy and Infectious Diseases, Bethesda, Md.). Virology; 40: 135-43(Jan 1970).

K virus-transformed mouse cells were obtained from cultures of infected lungs. Transformed cells had the following properties generally associated with viral transformation: altered morphology, immortality, ability to form colonies in soft agar medium,

and synthesis of a virus-specific intranuclear antigen detectable by either complement-fixation or fluorescent antibody tests. The nuclear antigen was relatively labile when heated at 56° for 30 min; evidence obtained indicated that it was not virion antigen. Cells cloned in the presence of K virus antiserum retained the capacity to synthesize the nuclear antigen. One line of transformed cells from C57 mice did not produce tumors when transplanted into syngeneic animals. The other line from Balb-c mice produced tumors in newborn or x-irradiated mice. Both lines were negative for infectious virus. (auth)

**17004** IMMUNOLOGICAL TOLERANCE AND INHIBITION BY HAPTEN. Boak, J. L.; Koelsch, E.; Mitchison, N. A. (National Inst. for Medical Research, London). Antibiot. Chemother.; 15: 98-109(1969).

Factors which control the induction of tolerance, with particular reference to radiosensitivity and persistence of antigen were considered. Irradiation of the macrophage donor at a suitable time before injection of antigen impedes the immunogenic activity of the cells. This finding was originally made with a Shigella antigen and was confined and extended with bovine serum albumin (BSA). With BSA there was an appreciable lag period before the effects of radiation appeared, and irradiation in vitro was not effective; this was not the case with Shigella, for reasons which are not clear. Most of the BSA first taken up by peritoneal macrophages was rapidly broken down, so that during the first 24 hr after injection the quantity of macrophage-bound antigen declined steeply, in parallel with the decline in extracellular concentration. The immunogenic capacity of the macrophage-bound BSA remained constant throughout this period, per unit weight, so that the net immunogenic capacity of the cells fell. There was some evidence of short-term retention of immunogenic capacity in the cells, based on the lack of activity of allogeneic cells, and of much longer term retention over a period of months. A proposed mechanism for the carrier effect involving co-operating antibody is explained, and the evidence in favor of this hypothesis is reviewed. Irradiation of the carrier-primed cells can, if performed at a suitable time and in suitable dose, reduce the anti-carrier response out of proportion to its co-operative effect on the anti-hapten response. (BBB)

**17005** IN VITRO AND IN VIVO STUDIES OF THE IMMUNE RESPONSE TO SHEEP ERYTHROCYTES USING PARTIALLY PURIFIED CELL PREPARATIONS. Haskill, J. S.; Byrt, Pauline; Marbrook, J. (Walter and Eliza Hall Inst. of Medical Research, Melbourne). J. Exp. Med.; 131: 57-76(1 Jan 1970).

The bovine serum albumin density-gradient technique for separating mouse spleen cells into partially purified populations was used to compare the responsiveness of such populations to sheep erythrocytes using in vivo and in vitro techniques. Two major populations were distinguished, one of which responded very well in vivo with an exponential dose response and poorly in vitro (fraction 3), and another which responded in vivo and in vitro with a linear dose response (fraction 2). A light density, x radiation-resistant component was identified which markedly stimulated the response of fraction 3 in vitro, and a density gradient profile was obtained for this cell which did not correspond with a macrophage profile. A high density, x radiation-sensitive cell was identified which stimulated the response of antibody-forming cells (PFC) precursors in lighter regions of the gradient. The activity of this cell could be replaced using thymus cells. A density profile for the PFC precursor cell was obtained by assaying small numbers of spleen cell fractions in the presence of an excess of the two auxiliary cell types. (auth)

**17006** RECOVERY OF IMMUNOCOMPETENCE OF BONE MARROW AND SPLEEN FOLLOWING SUBLETHAL IRRADIATION. Hayes, Lawrence L.; Claman, Henry N. (Univ. of Colorado, Denver). Proc. Soc. Exp. Biol. Med.; 133: 57-61 (Jan 1970).

The rates of recovery of mouse spleen and marrow cells after sublethal whole-body $^{60}$Co-γ irradiation were studied. Cells from donors given 500 R were transferred to lethally irradiated recipients at various times after donor irradiation. Donor spleen cells were given with sheep erythrocyte antigen (SRBC), while donor marrow cells were given with normal thymus cells and SRBC. The recovery rates of cellular proliferative ability, hematopoiesis (by $^{59}$Fe incorporation) and immunocompetence (by antibody formation to SRBC) were measured. The cellular proliferative ability and hematopoietic recovery were parallel; marrow cells had recovered by day 11 after irradiation (following an overshoot) while spleen cells had also recovered by day 11 but without overshoot. The marrow and spleen recovery rates of immunocompetence were markedly different, however. By day 11, marrow immunocompetence had reached normal levels while spleen immunocompetence was only 3.4% of normal. (auth)

**17007** STUDIES ON SYNERGISTIC THYMUS–BONE MARROW CELL INTERACTIONS IN IMMUNOLOGICAL RESPONSES. Davis, William E. Jr.; Cole, Leonard J.; Schaffer, Walter T. (Naval Radiological Defense Lab., San Francisco). Proc. Soc. Exp. Biol. Med.; 133: 144-50(Jan 1970).

Marrow cells and thymus cells that were exposed in vivo to SRBC antigen interact synergistically to produce hemolysin plaque-forming cells. The possibility of similar thymus-marrow cell interaction in producing cell mediated responses was tested in a variety of systems. Synergistic interactions were not observed: in the restoration of homograft reactivity of sublethally x-irradiated mice; in the production of graft-vs-host responses as measured by splenomegaly or of secondary disease; and in the restoration of the homograft response in sublethally irradiated, thymectomized recipients injected with marrow cells and with spleen cells from irradiated mice that were injected previously with thymus cells and weak isoantigen. A nonspecific stimulation of the homograft response did occur where the isoantigenic disparity was strong. This nonspecific stimulation offers perhaps the only other known evidence that thymus–marrow cell interactions are involved in cell-mediated immunological responses. Specific syngergistic interactions so evident in the initiation of the hemolysin response do not occur when cell-mediated immunological responses are tested under similar conditions. This does not definitely rule out the possibility that thymus marrow cell interactions are involved in cell-mediated immunological responses. Under certain conditions, thymus and bone marrow cell populations, like lymph node cell populations are each capable of conferring cell-mediated immunological competence. Hence these cell populations may have either one cell type capable of responding to isoantigen, or two or more cell types that interact to produce the response. (auth)

**17008** PATTERN OF STEM CELL REPOPULATION IN HEAVILY IRRADIATED MICE RECEIVING TRANSPLANTS OF FETAL LIVER. Kubanek, Bernhard; Rencricca, Nicholas; Porcellini, Adolfo; Howard, Donald; Stohlman, Frederick Jr. (Tufts Univ., Boston). Blood; 35: 64-7(Jan 1970).

Pluripotential cells derived from fetal liver had a lower plating efficiency than adult marrow cells, but estimates of the generation time derived from the growth curve were significantly shorter and may account for the earlier erythroid population. (auth)

**17009** EFFECT OF A SINGLE LARGE DOSE LOCAL X-RAYS ON ALLOGENEIC SKIN GRAFT REJECTION IN THE MOUSE. McCredie, John A.; Inch, W. Rodger; Sutherland, Robert M. (Univ. of Western Ontario, London, Can. Ontario Cancer Treatment and Research Foundation, London, Can.). Surg. Forum; 20: 283-4(1969).

From 55th Annual Clinical Congress, San Francisco, Calif. See CONF-691028–(Absts.).

Skin from female AKR/J mice was grafted to the interscapular region of C3H/HeJ mice. X rays were given to the interscapular region and to the axillary and cervical lymph nodes. The time of 100% graft rejection was determined. Local x-irradiation, 1500 Rad, to the allograft at one, 24, or 72 hr after operation increased graft survival compared with controls which received no irradiation. Treatment at one hr was most effective. Irradiation to the recipient site at 48 or one hr before operation increased graft survival compared with controls given the same dose to the caudal tissues, but was less effective than at one hr after operation. There was a rectilinear relation, at doses of 188 to 1500 Rad, between the dose of x rays and the day of rejection. Lymphopenia did not occur. Irradiation to the four limbs, 1000 Rad, was as effective as treatment to the graft. (auth)

## Ecology

**17010** (AD–695683) DEPOSITION AND RETENTION OF SIMULATED NEAR-IN FALLOUT BY FOOD CROPS AND LIVESTOCK. Technical Progress Report No. 1. Johnson, James E.; Lovaas, Arvin I. (Colorado State Univ., Fort Collins. Dept. of Animal Science). May 1969. Contract DAHC20-68-C-0120. 40p. CFSTI.

Simulated near-in fallout experiments were conducted using batches of 88-175u and 175-350u sand labelled with the low energy gamma-ray emitter, $^{177}$Lu (6.7 day half-life). Targets of field releases were alfalfa, pasture grass, field corn and grazing cows. Initial retention was determined by comparison with disc impactors and retention was measured as a function of time. Controlled deposition experiments were performed in a test chamber on corn, barley, tomatoes, beans and carrot plants. (auth) (TAB)

**17011** (AECL–3424) ECOLOGY OF THE FIELD IRRADIATOR-GAMMA AREA PRE-IRRADIATION STUDIES. I. PLANT

ASSOCIATIONS. Dugle, Janet R. (Atomic Energy of Canada Ltd., Pinawa (Manitoba). Whiteshell Nuclear Research Establishment). Oct 1969. 37p. Dep. CFSTI (U. S. Sales Only). AECL $1.00.

A circular area, 1000 m in diameter, was set aside as an ecological study preserve in the Whiteshell Nuclear Research Establishment controlled area, near Pinawa, Manitoba. Following intensive study a radiation source will be placed in the center and the effects of chronic irradiation on the biota will be examined. This report presents a brief description of some of the plant associations present. Picea mariana–Ledum–Sphagnum communities comprise approximately two-thirds of the preserve, while mixed forest associations containing Pinus divaricata, Abies balsamea, Betula papyrifera, and Populus tremuloides as dominant trees are included in the other third. The associations are compared to some that have been published for other areas in Manitoba. (auth)

**17012** (UCLA–12-761) DIFFERENTIAL EFFECT OF A CHRONIC DOSE OF GAMMA IRRADIATION ON SHRUBS IN THE NORTHERN MOJAVE DESERT. Kaaz, H. W.; Wallace, A.; Romney, E. M. (California Univ., Los Angeles. Lab. of Nuclear Medicine and Radiation Biology). [1969]. Contract AT-04-1-GEN-12. 14p. Dep. CFSTI.

A 33,600 curie $^{137}Cs$ γ source, which was differentially shielded to increase the uniformity of the distribution of irradiation, was set up on a 15-meter tower in the center of a 9-hectare plot in the Rock Valley Area of the Northern Mojave Desert in January 1964. In the spring of 1969 the large majority of 5000 Ephedra nevadensis within the plot failed to produce flowers and very little vegetative growth occurred in contrast to a control plot and to other nonirradiated areas. The cumulative irradiation dose throughout the plot ranged from 3000 to 29,000 R. Irradiation effects on Lycium andersonii were uncertain and effects were doubtful on other species. Ephedra nevadensis and L. andersonii have higher nuclear volume than do the other shrub species. Considerable resistance to gamma irradiation was observed for several of the other species present. (auth)

**17013** (UCLA–34-P-51-26) BEHAVIOR OF CERTAIN SYNTHETIC CHELATING AGENTS IN SOIL AND BIOLOGICAL SYSTEMS. Annual Progress Report. Wallace, Arthur (California Univ., Los Angeles). 1 Dec 1969. Contract AT(11-1)-34. 92p. Dep. CFSTI.

A study is in progress of the elucidation of principles involved in the effects of synthetic chelating agents on behavior in plants of heavy metals (including micronutrients) and of radionuclides of heavy metals found in fallout. The behavior of most concern is the uptake from soil and distribution in plants of these radionuclides. Past studies have indicated that certain synthetic chelating agents correct micronutrient deficiencies in plants. Some increase the uptake only of the metal with which the agent is chelated, while others have a great influence on uptake and distribution in plants of other heavy metals and also of some radionuclides which may be in the soil as the result of fallout contamination. An elucidation of the principles involved will help to predict what could happen to many radionuclides. The additions of some iron chelates to soil in high levels induces deficiencies of other micronutrients such as manganese. Progress to date of studies of this behavior indicates that only some agents have this effect and that it is related to levels applied. Other chelating agents even when applied with iron increase the uptake of the very elements that the other agents cause deficiencies for. The principles of these reactions were studied in an effort to predict behavior for any agent. As part of a total study of chelating agents in soil and in biological systems, the uptake and metabolism of the agents themselves were studied. Some attention was also directed towards the physiological effects of the metals themselves in plant nutrition. Interactions among metal and chelates, among different metals, and factors regulating the uptake of all are being considered. The chelating agents studied included DTPA, EDTA, EDDHA, ZnEDTA, ZnNTA, and $ZnSO_4$. Data are reported on the effects of DTPA on the uptake of $^{241}Am$, $^{137}Co$, $^{55}Fe$, $^{210}Pb$, and $^{65}Zn$ by orange leaves immersed in solutions containing the radioisotopes; the effects of DTPA on the uptake of $^{241}Am$, $^{137}Co$, $^{203}Hg$, $^{210}Pb$, and $^{125}Sb$ by bush beans growing in two types of loam soil; and the effects of EDTA with the addition of Ca on the uptake of $^{64}Cu$ and $^{65}Zn$ by bush beans (Phaseolus vulgaris). (C.H.)

**17014** RETENTION OF $^{51}Cr$, $^{59}Fe$, $^{60}Co$, $^{65}Zn$, $^{85}Sr$, $^{95}Nb$, $^{114m}In$, AND $^{131}I$ BY THE ATLANTIC CROAKER (MICROPOGON UNDULATUS). Baptist, J. P.; Hoss, D. E.; Lewis, C. W. (Bureau of Commercial Fisheries, Beaufort, N. C.). Health Phys.; 18: 141-8 (Feb 1970).

Evaluation of the possible effects of radioactive effluents on fisheries and, ultimately, the potential hazards to people requires a knowledge of the retention of radionuclides by fish. We measured retention of $^{51}Cr$, $^{59}Fe$, $^{60}Co$, $^{65}Zn$, $^{85}Sr$, $^{95}Nb$, $^{114m}In$ and $^{131}I$ in croaker at ambient temperatures and salinites of local waters following single intraperitoneal injections. We also measured retention of $^{85}Sr$ and $^{131}I$ in various croaker tissues. Retention of all nuclides, except $^{60}Co$ and $^{131}I$, was expressed as two exponential rate functions. Cobalt-60 retention was expressed as a single rate function, and $^{131}I$ as three rate functions. Biological half-lives of long-lived components were as follows: $^{51}Cr$ 70 days; $^{59}Fe$ 215; $^{60}Co$ 31; $^{65}Zn$ 138; $^{85}Sr$ 138; $^{95}Nb$ 465; $^{114m}In$ 224; and $^{131}I$ 24 days. Effective half-lives of the same components were as follows: $^{51}Cr$ 20 days; $^{59}Fe$ 37.2; $^{60}Co$ 30.5; $^{65}Zn$ 88.3; $^{85}Sr$ 44.2; $^{95}Nb$ 32.6; $^{114m}In$ 40.2; and $^{131}I$ 6 days. It was concluded that fish containing large amounts of radionuclides with long effective half-lives, such as $^{55}Fe$, $^{65}Zn$, and $^{90}Sr$, may be hazardous to public health. (auth) (UK)

**17015** SOURCES OF $^{210}Pb$ IN URANIUM MINERS. Holtzman, Richard B. (Argonne National Lab., Ill.). Health Phys.; 18: 105-12(Feb 1970).

The concentrations of $^{226}Ra$ and $^{210}Pb$ were determined in bone samples from seven uranium miners. The ratios of the specific activities of the $^{210}Pb$ to those of the $^{226}Ra$ were used to show that on the average about 9% of the $^{210}Pb$ in these miners originated from the inhalation of uranium ore dust. Estimates are presented of possible sources of the $^{210}Pb$ found in the bones of uranium miners. The fractional contributions of the major sources are estimated to be 43% from the short-lived $^{222}Rn$ daughters inhaled from the atmosphere, 9% from inhaled ore dust, 18% from $^{210}Pb$ in the atmosphere, and 30% from $^{222}Rn$ dissolved in body fluids. (auth) (UK)

**17016** RADIATION-INDUCED ANATOMICAL MODIFICATIONS IN FOREST TREES. Witherspoon, J. P.; Taylor, F. G. Jr. (Oak Ridge National Lab., Tenn.). J. Tenn. Acad. Sci.; 44: 118-24(Oct 1969).

Aberrant stem and foliage samples were collected from several forest tree species irradiated by fast neutron or $^{60}Co$ gamma sources. Common gross morphological abnormalities such as fused stems, alterations of size and shape of leaves and necrosis in meristematic regions were examined microscopically. These frequently reported changes in plant growth habit were described by effect of radiation on internal structure. Probable effects of these tissue changes on the physiological function of organs are discussed. Of particular significance were anomalies in vascular tissues of foliage which could effect the transport of both mineral and food substances. (auth)

**17017** RADIATION RISK: A SCIENTIFIC PROBLEM. Holcomb, Robert W. Science; 167: 853-5(6 Feb 1970).

The assumption is made that the relation between low level radiation doses and effects such as incidence of leukemia and several other forms of cancer is linear, that there is no threshold below which radiation has no effect, and that there is no regenerative effect at low dose rates. The data used to substantiate this assumption are cited, and the statistical impact on the human population when the data are applied is examined, as is the rationale underlying the argument for immediate reduction of the FPC's allowable dose of 0.17 rad per year to the population at large by a factor of 10. The opinions of scientists associated with the establishment of radiation standards are referred to, and serious questions are raised regarding the validity of making extrapolations from data on high dose effects to low dose effects, from data on genetic effects to somatic effects, and from data on increased incidence of some forms of cancer due to radiation exposure, as reported by the Atomic Bomb Casualty Commission, to increases in all forms of cancer due to radiation in proportion to their natural incidence. It is concluded that the possibility of confirming or refuting the existence of a linear relation between dose and effect at low radiation levels by epidemiological studies is remote. The term acceptable risk, as used in radiation standards, could mean a risk that is actually present but that cannot be demonstrated to exist by scientific studies. (E.R.B.)

**17018** DO COSMIC PHENOMENA INFLUENCE THE GROWTH OF LIVING CREATURES? Verfaillie, Georges (EURATOM-ITAL, Wageningen, Netherlands). Euro-Spectra; 8: 106-11(Dec 1969).

The radiations reaching us from outer space have long formed part of that category of semi-occult phenomena on which it was tempting to lay the responsibility for all sorts of events, almost exclusively unpleasant, which could not be accounted for otherwise. Even in our time they have not lost all their mystery, especially as regards their effects on living creatures. Results are reported from studies on the growth of rice plants that indicate that certain radiations of solar origin have a considerable adverse influence on the growth of plants. It remains to be seen whether they affect all living creatures to such a marked extent, and more particularly man. This is a question which it seems essential to answer, espe-

cially as there is today a widely growing awareness of the problems posed by our environment. (auth)

**17019** $^{90}Sr$ AND $^{137}Cs$ IN HUMAN AND OTHER MILKS COLLECTED IN ALASKA. Baker, B. E. (McGill Univ., St. Anne de Bellevue, Quebec).; Neilson, C. H.; Samuels, E. R. J. Dairy Sci.; 53: 241-4(Feb 1970).

Strontium-90 and $^{137}Cs$ were determined in 40 samples of human milk obtained from 21 different communities in Alaska, as well as in polar bear, dall sheep, and harp seal milk. The average $^{137}Cs$ content (pCi per gram of ash) of all samples of human milk collected in Alaska in 1968 was only 3.3% of the average value for all samples of human milk collected in the Northwest Territories in 1967. The average $^{90}Sr$ content of the same Alaskan milks was about 10% higher than that of the human milk collected in the Northwest Territories. (auth)

**17020** DISTRIBUTION OF C, H, N, P, Fe, Mn, Zn, Ca, Sr, AND Sc IN PLANKTON SAMPLES COLLECTED OFF PANAMA AND COLOMBIA. Martin, John H. (Puerto Rico Nuclear Center, Mayaguez). Bioscience; 19: 898-901(Oct 1969).

As part of a feasibility study of nuclear excavation of a sea level canal, 130 plankton samples were collected on both sides of the Isthmus of Panama, during the wet and dry seasons, and later analyzed from 10 elements: Fe, Mn, Zn, Ca, Sr, Sc, P, H, C, and N. The elemental distribution patterns obtained from 1300 analyses are presented along with a discussion of the more important environmental factors that affect the concentration of each element, in a given area, at a given time. Because of the various factors described and the many environmental conditions affecting them, the causes for the distribution of elements within the plankton samples are complex. Simple explanations are often impossible. However, matters will be clarified when the factors affecting elemental abundance in the seawater and in the sediments are discussed in reference to the physical environment. (BBB)

## Genetics and Cytogenetics

*Refer also to abstracts 16954, 16996, 17160, and 17183.*

**17021** (UCRL-Trans-10442) CHROMOSOME ANOMALIES IN PERSONS WORKING UNDER CONDITIONS OF EXPOSURE TO IONIZING RADIATION. Zhivkov, St.; Kirov, K.; Donev, Iv.; Bulanov, Iv. Translated by B. J. Hazzard for Univ. of California Lawrence Radiation Lab., Livermore, from Suvrem. Med.; 19: No. 5, 445-52(1968). 10p. Dep. CFSTI.

Structural and numerical chromosomal abnormalities were found in cultured leucocytes from 34% of the person tested who had worked for two years under conditions of exposure to ionizing radiation and had received a mean annual dose of 17 to 682 millirads. The results indicate that small doses of ionizing radiation can produce chromosomal changes in human somatic cells. (auth)

**17022** CHROMATID ABERRATIONS INDUCED BY 14.1-MeV NEUTRONS IN VICIA FABA ROOT MERISTEM CELLS. Savage, J. R. K. (Medical Research Council, Harwell, Eng.). pp 9-28 of Neutron Irradiation of Seeds. Pt. II. Vienna; International Atomic Energy Agency (1968).

From FAO/IAEA Meeting on Co-ordination of Research on the Use of Neutrons in Seed Irradiation, Vienna, Austria. See STI/DOC-10/92; CONF-671221.

The types and relative frequencies of chromated aberrations induced by doses of 16.3 and 48.2 rad of 14.1-MeV neutrons in the primary root meristem cells of Vicia faba were studied. Fixations were made at hourly intervals from 3 to 9 hours post irradiation to cover cells which were in G2 and late S at the time of treatment. Frequency changes with time show similar trends to those found after X-rays in this material under similar conditions, most aberration types showing a definite peak of sensitivity in early to mid G2 and a decline in S. A detailed cytological analysis of the Revell intra-change types provides evidence of the importance of the high LET particles (which result from inelastic collisions) in the production of chromosomal aberrations with this quality of neutrons. The findings give further support to the theory that the effective LET of 14.1-MeV neutrons in biological materials is higher than one would expect from a consideration of recoil proton energies alone. (auth)

**17023** EFFECTS OF PILE NEUTRON AND X-RAY IRRADIATIONS ON RICE. Kawai, T. (National Institute of Agricultural Sciences, Hiratsuka, Japan). pp 39-41 of Neutron Irradiation of Seeds. Pt. II. Vienna; International Atomic Energy Agency (1968).

From FAO/IAEA Meeting on Co-ordination of Research on the Use of Neutrons in Seed Irradiation, Vienna, Austria. See STI/DOC-10/92; CONF-671221.

Air-dry seeds of rice were exposed to pile neutrons and to X-rays. Effects of the treatments on $R_1$ plant and mutation frequency were studied. X-rays gave a higher frequency (3.8%) of mutants considered beneficial than did pile neutrons (2.8%). (auth)

**17024** SOME EFFECTS OF FAST NEUTRONS AND GAMMA RADIATION ON RICE. Mikaelsen, K.; Kiss, I.; Osone, K. (International Atomic Energy Agency, Vienna). pp 49-54 of Neutron Irradiation of Seeds. Pt. II. Vienna; International Atomic Energy Agency (1968).

From FAO/IAEA Meeting on Co-ordination of Research on the Use of Neutrons in Seed Irradiation, Vienna, Austria. See STI/DOC-10/92; CONF-671221.

Seeds of the Hungarian rice variety, Dungham Shali, were irradiated with doses of gamma radiation and fast neutrons. The effects of the irradiation on seedling growth, plant survival, fertility, and on chlorophyll mutations in $M_2$ plants were studied. At the optimal dose level for mutation production in this material, fast neutrons produced 2-3 times more chlorophyll mutations than gamma irradiation. (auth)

**17025** MODIFYING THE EFFECTS OF FAST NEUTRONS IN RICE SEEDS BY POST-TREATMENT WITH CHEMICAL MUTAGENS. Soriano, J. D. (Univ. of the Philippines, Quezon City). pp 55-62 of Neutron Irradiation of Seeds. Pt. II. Vienna; International Atomic Energy Agency (1968).

From FAO/IAEA Meeting on Co-ordination of Research on the Use of Neutrons in Seed Irradiation, Vienna, Austria. See STI/DOC-10/92; CONF-671221.

Dormant rice seeds were exposed to 290-1160 rad of neutrons, dehulled, and then soaked in buffered aqueous solutions of either 0.03M EMS or 0.005M MMS for 15 h at 30°C. The neutron plus EMS treatment did not affect seedling height and seedset as much as did the neutron plus MMS treatment, which caused marked reductions over those due to neutrons alone. The mutation frequency ($M_{sp}$) in all neutron doses was slightly to markedly increased by EMS, and reduced by MMS. Neutrons + EMS was found to be an efficient mutagenic combination whereas neutrons + MMS was inefficient ($M_{sp}/I$). Differences in the synergistic effects of these combined treatments may be due to the specific biological action of the chemicals as determined by their physical properties. The possibility that the chemicals may have acted essentially as selective factors for survival of neutron-damaged or mutated tiller initials is briefly discussed. (auth)

**17026** IRRADIATION OF SEEDS. A REVIEW OF PROCEDURES EMPLOYED AT WASHINGTON STATE UNIVERSITY. Konzak, C. F.; Bottino, P. J.; Nilan, R. A.; Conger, B. V. (Washington State Univ., Pullman). pp 83-96 of Neutron Irradiation of Seeds. Pt. II. Vienna; International Atomic Energy Agency (1968).

From FAO/IAEA Meeting on Co-ordination of Research on the Use of Neutrons in Seed Irradiation, Vienna, Austria. See STI/DOC-10/92; CONF-671221.

Experimental techniques used by the authors for radiobiological studies in barley are described. These include selection and threshing of seed stocks, irradiation procedures under controlled conditions of moisture content, oxygen, and temperature, and the rehydration and culturing of irradiated seeds. Field planting of such treated seed, harvest of $M_1$ apical spikes, and subsequent planting and counting of $M_2$ chlorophyll mutants also is discussed. Application of computers to the statistical analysis of mutation frequency is outlined. (auth)

**17027** DOMINANT LETHAL MUTATIONS AFTER IRRADIATION OF MOUSE SPERMATOGONIA WITH 600 R OF X-RAYS. Schroeder, Johannes Horst (Gesellschaft fuer Strahlenforschung mbH, Neuherberg, Ger.). Int. J. Radiat. Biol.; 16: 377-87(1969).

Male (101♀ × C3H♂) $F_1$ hybrid mice were irradiated with 600 R of x rays when 10 to 12 weeks old. One group was exposed to whole-body irradiation, whereas a second group had their gonads irradiated while the trunk was shielded with lead. A third control group remained untreated. At different weeks after regaining their fertility, the irradiated males were mated to either virgin C3H inbred females or to (101♀ × C3H♂) $F_1$ hybrid females. The females were dissected 13.5 to 16.5 days after the appearance of a copulative plug. The numbers of corpora lutea, implants, dead and living embryos were determined. Significant differences concerning both the post- and pre-implantational losses as well as the live embryos were found only between the irradiated series and the controls. More pre-implantational losses occurred after the irradiation of males which were mated immediately after regaining their fertility than after the mating of older ones with a greater interval after irradiation. The fraction of pre-implantation losses was also higher after isolated gonad irradiation than after whole-body exposure and after mating irradiated males to C3H inbred females than to (101♀ × C3H♂) $F_1$ hybrid females. Some further

differences of post- and pre-implantational losses did not reach significant levels. (auth) (UK)

**17028** ISOLATION OF X RAY SENSITIVE MUTANTS OF SACCHAROMYCES CEREVISIAE. Suslova, N. G. (Ioffe Inst. of Physics and Tech., Leningrad). Radiobiologiya; 9: 933-6(Nov-Dec 1969). (In Russian).

Among yeasts Saccharomyces cerevisiae 14 x-ray sensitive mutants were isolated. The uv-sensitive haploid cells served as starting material. The mutants were induced with uv rays and selected by the method of replica plating. The property of sensitivity to the lethal effects of x rays is manifested in the mutants only in the case of irradiation on agar. Among the mutants the dose dependence of the survival is changed. (tr-auth)

**17029** INFLUENCE OF THE MOISTURE CONTENT AND OXYGEN ON THE MANIFESTATION OF THE DOSE RATE EFFECT IN THE IRRADIATION OF DORMANT PEA SEEDS. Tsarapkin, L. S.; Tsarapkina, K. A. (Inst. of Medical Radiology, Obninsk, USSR). Radiobiologiya; 9: 882-7(Nov-Dec 1969). (In Russian).

Dry (5 to 8% water) and moist (13 to 19% water) dormant seeds were irradiated with $\gamma$ rays from $^{60}$Co at dose rates of 34 to 42 and 3600 to 4200 Rad/min. The chromosome aberrations were determined in the anaphases of the root meristem, fixed at the end of the first cycle of cell division after soaking of the seeds. The lower cytogenetic effectiveness of $\gamma$ rays at 4200 Rad/min was manifested only on moist seeds. The composition of the gas medium (oxygen, air, argon) did not influence this phenomenon. It is proposed that this phenomenon arises from recombination of radicals. (tr-auth)

**17030** TIME EFFECT OF X RAYS ON THE INDUCTION OF CHROMOSOMAL ABERRATIONS IN SWINE. Oprescu, S. Rev. Zooten. Med. Vet.; 18: No. 12, 34-41(1968). (In Rumanian).

Subsequent to an x-ray treatment applied to controls, the chromosome count varied from 36 to 40. In animals submitted to a milder treatment the same count ranged between 35 to over 41. The occurrence of a differentiated polyploid was also noted. The number of cells with $2n = 38$ chromosomes decreased from 97.77 per cent in controls to 85.23 per cent in the animals exposed to 600 R. The number of aberrant metaphases increased with the dose, being higher at 24 h after irradiation than after 48 h. Among the types of chromosomal aberrations that were more significant in the x-ray-treated groups hexaploid metaphases (for the 600 R dose), as well as an increased number of acentric chromosome fragments, were noted. (auth) (Rom. Sci. Abstr.)

**17031** ON THE FUNCTION OF THE N CISTRON IN PHAGE LAMBDA. Schwartz, Maxime (Harvard Univ., Cambridge, Mass.). Virology; 40: 23-33(Jan 1970).

An in vivo assay for the product of the N gene of bacteriophage $\lambda$ is described. Using this assay it was shown that expression of the N gene starts during the first minute of the vegetative cycle; the N product is functionally unstable between 30° and 35° but stable at 4°; the phage repressor prevents expression of the early genes located to the left of N, even in the presence of N product; and the amount of N product synthesized by wild-type phage $\lambda$ is in large excess of what is required to obtain maximum expression of the early genes located to the left of N. (auth)

**17032** CHARACTERIZATION OF REP$^-$ MUTANTS AND THEIR INTERACTION WITH P2 PHAGE. Calendar, Richard; Lindqvist, Bjorn; Sironi, Gianpiero; Clark, Alvin J. (Karolinska Inst., Stockholm. Univ. of California, Berkeley). Virology; 40: 72-83(Jan 1970).

Three rep$^5$ mutations in Escherichia coli were mapped between metE and ilv, rep is recessive. Using REP$^-$ strains derived by transduction, no evidence was obtained that three rep mutations confer recombination deficiency, although they do appear to confer a slight increase in uv sensitivity. A number of temperate coliphages cannot use REP$^-$ mutants as a host in lytic multiplication. The interaction of REP$^-$ mutants and the non-inducible temperate phage P2 is examined in detail, with the following findings: P2 can inject its DNA into REP$^-$ hosts, and the phage DNA can circularize, but replication of the DNA is blocked; P2 can lysogenize REP$^-$ mutants at approximately normal frequency; and REP$^-$ mutants are resistant to killing by P2. (auth)

**17033** CHROMOSOMAL ABERRATIONS IN THE HEMATOPOIETIC MOUSE TISSUES FOLLOWING LETHAL DOSE OF X-RAYS AFTER TRANSFUSION OF THROMBOCYTES. Muramatsu, S.; Nakamura, W.; Eto, H. (Institut National des Sciences Radiologiques, Chiba, Japan). Compt. Rend. Soc. Biol., 163: No. 1, 243-8(June 16, 1969). (In French).

An analysis of the caryotype was made in cells of the spleen and bone marrow of 11 to 12 week old male mice of the ddN strain, which after transfusion of female blood platelets, had received a lethal dose of 900 rad x rays five days before sacrifice. The examined cells had Y chromosomes which indicated that they had not been accidentally contaminated with those of the donors. While Y chromosomes are in general not radiation sensitive, they showed nevertheless characteristic radioinduced aberrations. In spite of this damage, those found in hematopoietic tissues were able to restore the damage, using factors provided by blood platelets. Abnormal Y chromosomes were found frequently in both spleen and bone marrow tissues that indicated a characteristic sequence of alterations. This study proved that, contrary to the opinion of other researchers, the Y chromosome is a valuable cytologic marker in the study of radiation effects. (F.J.W.)

**17034** CHROMOSOMAL ABERRATIONS IN A RADIATION ACCIDENT. DOSIMETRIC AND HEMATOLOGICAL ASPECTS. Schneider, G. J.; Chone, B.; Bloennigen, T. (Univ., Freiburg i. B. Univ., Heidelberg). Radiat. Res.; 40: 613-17(Dec 1969).

In a radiation accident with a 192-iridium rod one person was exposed to a $\gamma$-irradiation of a physically estimated local exposure of 4,000 to 6,000 R on the pelvic region. From this a whole-body dose of 100 rads was calculated. A bone-marrow sample exhibited typical cytomorphological alterations. The chromosome analysis revealed characteristic radiation-induced chromosome aberrations. On the basis of the aberration yield a dose in the range of 100 to 125 rads was estimated. This was in good agreement with the physical-dose estimation. Among eight deleted G-chromosomes, four were found to be morphologically similar to the Ph$^1$-chromosome in chronic myeloid leukemia. (auth)

**17035** INFLUENCE OF ANIMAL AGE ON RADIATION-INDUCED CHROMOSOME ABERRATIONS IN SWINE LEUKOCYTES. McFee, A. F.; Banner, M. W.; Sherrill, Mary N. (UT-AEC Agricultural Research Lab., Oak Ridge, Tenn.). Contract AT-40-1-GEN-242. Radiat. Res.; 41: 425-35(Feb 1970).

Chromosome aberrations were scored in swine leukocytes after an in vitro exposure to 300 R of $\gamma$ radiation. Six pigs were sampled periodically from 4 through 72 weeks of age; a second group was sampled at 11.0 and 11.5 years. Coefficients of two-hit aberration production were relatively high in young animals, fell somewhat as the animals matured, and increased slightly with advanced age. Although the coefficients for one-hit aberrations remained fairly constant, the contribution of achromatic lesions within this category was significant among young pigs but nonexistent in mature animals. Among the control samples, spontaneous chromosome deletions rose slightly in cells from mature animals; other types of anomalies showed no relationship to animal age. Chromatid aberrations, which are not normally considered to be radiation-related in these cells, showed increases among irradiated samples from older pigs. (auth)

**17036** RADIATION-INDUCED GYNOGENESIS AND ANDROGENESIS IN FISH. Purdom, C. E. (Ministry of Agriculture, Fisheries and Food, Lowestoft, Eng.). Heredity; 24: 431-44 (1969).

A major difficulty in selective breeding of fish is the long generation time of three yrs or more. The possibility was investigated of producing homozygous clones of fish rapidly by gynogenesis (artificial parthenogenesis in which activation of the eggs is achieved by fertilization with genetically inert spermatozoa). Eggs of trout (Salmo trutta), plaice (Peuronectes platessa), and flounder (Platichthys flesus) were successfully fertilized by spermatozoa exposed to $^{60}$Co $\gamma$-ray doses of from $10^4$ to $10^5$ rad. Typical Hertwig phenomena were observed, with survival increasing with increasing dose, suggesting that the developing embryos at high radiation doses were gynogenetic. Gynogenetic embryos were of two types, corresponding closely to haploid and diploid syndromes in parthenogenetic frogs. Haploidy of grossly abnormal trout gynogenomes and diploidy in near-normal gynogenomes were indicated by a comparison of nuclear sizes in late embryos. Viability of diploid gynogenomes was very low and the individuals were not completely normal but showed many minor abnormalities comparable to inbreeding effects in lab fish. The normal incidence of diploid as opposed to haploid gynogenesis was less than 1%, but this could be increased to 60% or more by application of a cold shock 20 min after fertilization. Androgenesis in irradiated flounder eggs produced only haploid embryos, whether the eggs were cold-shocked or not. Gynogenesis offers a rapid means of developing inbred material without the delay associated with normal systems of inbreeding. (BBB)

**17037** ULTRAVIOLET-INDUCED MUTATION AND DNA REPAIR. Witkin, Evelyn M. (State Univ. of New York, Brooklyn). Annu. Rev. Genet.; 3: 525-52(1969).

Enzymatic DNA repair and its role in uv-light-initiated mutagenesis in Escherichia coli are reviewed, with 103 references. Three repair mechanisms are now known in E. coli, each of which promotes survival after uv exposure. Two of the 3 (photoreactivation and excision repair) eliminate pyrimidine dimers from the DNA; the third (postreplication repair) does not act on the primary uv photoproducts, but on secondary lesions (single-strand gaps) induced by unrepaired pyrimidine dimers in replicating DNA. A summary of each of these mechanisms is given. Pyrimidine dimers repaired by photoreactivation or by excision repair are much less likely to cause mutations than unrepaired pyrimidine dimers remaining in the DNA and passing through the replication machinery. Unrepaired pyrimidine dimers (and possibly other unrepaired uv photoproducts) cause mutations by inducing the formation of daughter strand groups, one gap opposite each unrepaired lesion. These gaps, which are lethal if not repaired, cannot be mended by repair replication because each is located opposite a noncoding lesion. They are repairable only by a mechanism that probably involves some form of genetic recombination between complementary daughter strands, one of which is always intact in a region where the other has a gap. Most uv-induced mutations are errors introduced into the DNA in the course of inaccurate recombinational repair of single-strand gaps. (BBB)

17038 ULTRAVIOLET-INDUCED REVERSIONS OF SALMONELLA HIS FRAMESHIFT MUTATIONS. Kanazir, Dusan T.; Hartman, Philip E.; Savic, Dragutin (Johns Hopkins Univ., Baltimore). J. Bacteriol.; 101: 649-51(Feb 1970).

Ultraviolet light elicits reversions in 12 his frameshifts that also revert in response to ICR191. Reversion also is stimulated by uv irradiation in two of four spontaneously revertible, but ICR-negative, frameshifts. (auth)

# Health Physics and Safety

*Refer also to abstracts 16412 and 17265.*

## Radioactive Contamination and Decontamination

*Refer also to abstracts 16634, 16651, 17010, and 17013–17015.*

17039 CONTAMINATION OF MILK. Manuta, G. (Univ., Sassari, Italy). Minerva Med., 60: 1505-6(Apr. 18, 1969). (In Italian).

The need for the continuous monitoring of milk to assure its purity from contamination with radioactive isotopes—particularly $^{137}Cs$, $^{90}Sr$, and $^{131}I$—and also its purity from pesticides such as DDT is stressed. The need for additional studies to determine the toxicity of the DDT residues in milk and the contamination of milk with antibiotics is also considered. (J.S.R.)

17040 NATURAL GAMMA RADIATION IN NORTHEAST AND EAST-CENTRAL GEORGIA. Ritchie, Jerry C.; Plummer, Gayther L. (Univ. of Georgia, Athens). Bull. Ga. Acad. Sci.; 27: 173-94(Sep 1969).

Thorium, uranium and potassium (all naturally occurring), and beryllium-7, cesium-137, ruthenium-106, cerium-144, antimony-125, zirconium-niobium-95 and manganese-54 (all from fallout) were found in soil samples collected in northeastern and east-central Georgia. Thorium concentrations ranged from 3 to 70 ppM with an average concentration of 15.8 ppM. Uranium concentrations varied from 1 to 10 ppM with an average of 3.7 ppM. The average thorium to uranium ratio was 4.3 : 1. Total potassium ranged from non-detectable levels to 4.8% with an average of 1.08%. Concentrations of thorium and uranium in granitic outcrop soils were the same as non-outcrop soils. Potassium concentrations in granitic outcrop soils were three times that of non-outcrop soils. Cesium-137 concentrations in outcrop soils were ten times greater than that in non-outcrop soils. Although concentrations given in this report cannot be considered as absolute values, they are good estimates of the thorium, uranium and potassium at the particular locations sampled and are probably representative of concentrations elsewhere in northeastern and east-central Georgia. Average concentrations of thorium and uranium were higher in the study area than those reportedly found in the world-wide lithosphere and soil. One probable cause for higher concentrations is the occurrence of monozite in the Georgia Piedmont. Commercially mineable uranium ores are usually at least 100 times more concentrated than any concentrations found in the study area. Neither uranium nor thorium is an active metabolite in plants or animals. Although uranium is more mobile than thorium in soils, neither uranium nor thorium concentrations are high in plant or animal tissues; therefore, they cannot be considered of great importance in biological food chains. Potassium, on the other hand, is mobile in the soil, and is an active metabolite. Total gamma radiation (0-2.70 MeV) ranged from 550 to 8900 CPM/kg or a 16-fold range in activity. Calculated dose rates ranged from 2.25 to 38.30 μR/hr or a 17-fold range. The average dose rate for the 132 soils was 10.65 μR/hr. Distribution of thorium, uranium and potassium followed broad geologic patterns. Concentrations of these elements were lowest in the sandy materials of the Coastal Plain and highest in the basic igneous-metamorphic material of the Piedmont. Distribution of thorium, uranium and potassium in four soil series was best related to geologic parent material. The Piedmont soils, Appling, Madison and Cecil, had higher concentrations than sandy Norfolk soils of the Coastal Plain. A high correlation (r = 0.88) was found between aerial gamma radioactivity and dose rates indicating that gamma aeroradioactivity maps can be used to delineate areas with different background radiation. (auth)

## Dosimetry and Monitoring

*Refer also to abstracts 16835, 16894–16896, 17017, 17108, 17156, and 17160.*

17041 THE MEASUREMENT OF RADON EMANATION RATES IN A CANADIAN URANIUM MINE. Thompkins, R. W. (Queen's Univ., Kingston, Ont.). (CIM Can. Mining Met.) Bull.; 62: 1356-62(Dec 1969).

Radon gas emanates into uranium mines from the rock walls or from the faces of broken ore lying in the stope. It is the source of the radon daughters, which in turn are the elements that produce physiological damage in the lungs and which are the source of the definition of a working level of radiation. Knowledge of the rate of emanation is essential to the design of mine ventilation systems for uranium mines. The method being used at Elliot Lake to measure the emanation of radon gas is described. (auth) (Canada)

17042 METHOD FOR LEAK TESTING RADIUM SOURCES. Angleton, George M. (Colorado State Univ., Fort Collins). Health Phys.; 18: 160-2(Feb 1970).

A system for leak testing radium sources is described, consisting of a source chamber and ion chamber instrument, through which filtered air was continuously recirculated, together with a recorder to monitor the concentration of radon in the system. This equipment had a maximum working sensitivity of about 50 pCi for leak testing radium sources. It could also be used for monitoring atmospheric concentrations of radon or thoron in the neighborhood of 50 pCi/l and in a slight radiation field. (UK)

17043 A STUDY OF THE TWO-FILTER METHOD FOR $^{222}Rn$. Thomas, Jess W. (Atomic Energy Commission, New York); LeClare, Philip C. Health Phys.; 18: 113-22(Feb 1970).

A basic equation for calculating $^{222}Rn$ concentration in air using the two-filter method with $\alpha$ counts of the exit filter has been developed, eliminating the need for calibrations. The equation takes into account the sampling time, counting time, flow rate, tube length, and volume, and includes a correction factor for diffusion loss in the two-filter tube. An experimental confirmation of the equation was obtained over a wide range of variables by comparing radon concentrations with a National Bureau of Standards source, when the diffusion rate of radium-A was taken to be 0.085 $cm^2/sec$. This value is considerably higher than the values cited in the literature which, however, were obtained with older radium-A atoms. Variations in relative humidity did not affect results in the 20 to 90% range. The two-filter method having the important advantage of simplicity, not requiring specialized instrumentation, or elaborate gas handling techniques, is also accurate as shown by the verified basic equation developed in this work. Calculations have indicated that the sensitivity of the method is in the range of 0.1 to 10 pCi/l of radon, depending on tube size, sampling time, and counting time. (auth) (UK)

17044 RBE, LET, AND z/B. Katz, Robert (Univ. of Nebraska, Lincoln). Health Phys.; 18: 175(Feb 1970).

Following a request (Turner, J. E.; Hollister, Hal, Health Phys. 17: 356 (1969)) that a suitable combination of charge and velocity be found to replace LET, it is pointed out that no single combination of these variables can fully characterize track effects, as these are affected by the ratio of the range $r_m$ of the delta ray of maximum energy to the radius $a_0$ of the sensitive volume. (UK)

17045 RECOMMENDATIONS FOR PERSONNEL MONITORING IN DIAGNOSTIC RADIOLOGY. Bushong, Stewart C.; Harle, Thomas S.; Pogonowska, Magdalena J. (Ben Taub General Hospital, Houston, Tex. Baylor Coll. of Medicine, Houston, Tex.). Phys. Med. Biol.; 15: 91-7(Jan 1970).

Most radiation exposure to diagnostic radiologists occurs during

fluoroscopy when the radiologist is wearing protective apparel. This perturbs the normal radiation field, making it difficult to determine the most appropriate place to wear a film badge. To answer this problem 15 radiologists were monitored at 27 different anatomical locations for 6-monthly intervals. The data showed dose equivalent levels of the total body badges ranging from 0.017 to 1.58 mrem per minute of beam-on time. The levels of the extremity monitors range from 0.218 to 4.699 mrem per minute. Based on these data it is recommended that: if only one badge is worn, it should be worn on the front collar; both hands should be gloved; the placement of the film badge should be an integral part of the personnel monitoring record. (auth) (UK)

**17046** AVERAGE DOSES TO THE RADIOLOGIST IN CONTRAST-MEDIA STUDIES OF THE GASTROINTESTINAL TRACT, LOWER EXTREMITY VENOGRAPHY, AND URETHROCYSTOGRAPHY. Rytilae, A.; Perttala, Y. (University Central Hospital, Helsinki). Health Phys.; 18: 123-5(Feb 1970).

The doses to which an examining radiologist is subjected were measured by fluoro-glasses during 100 contrast-media studies of the gastrointestinal tract, 100 lower extremity venographies, and 50 urethrocystographies on male patients. The maximum doses were measured on the forehead, the forearms, and the shoulders. The average dose of $\gamma$ radiation accumulated in the forehead in a single contrast-media study of the gastrointestinal tract was about 0.1 mrems, 10 rems in venography, and 30 mrems in urethrocystography. (auth) (UK)

**17047** FACILITY FOR SEED IRRADIATION WITH FAST NEUTRONS IN TRIGA-TYPE REACTORS. Casta, J. (Oesterreichische Studiengesellschaft fuer Atomenergie G.m.b.H., Reaktorzentrum, Seibersdorf, Austria). pp 113-21 of Neutron Irradiation of Seeds. Pt. II. Vienna; International Atomic Energy Agency (1968).

From FAO/IAEA Meeting on Co-ordination of Research on the Use of Neutrons in Seed Irradiation, Vienna, Austria. See STI/DOC-10/92; CONF-671221.

Proposals are made for a facility for seed irradiation with fast neutrons in TRIGA-type reactors based on measurements in the TRIGA-Mark II in Vienna and on the experience gained with a seed irradiation facility used since November 1966 in the ASTRA reactor in Seibersdorf. Three lead- and boron-shielded facilities of varying diameters and one uranium-shielded facility are proposed. A comparison of these facilities reveals that the uranium-shielded one has the best physical properties. It is smaller than the lead-shielded facility, provides better gamma shielding, reduces the thermal neutron flux without any additional absorption material and increases the fast-neutron dose. But the choice of type of facility has to be made individually at each TRIGA reactor station, depending upon the space available in the pool of the reactor and the funds available for the facility. (auth)

**17048** SOME COMMENTS ON THE OUTPUT OF DIFFERENT X-RAY MACHINES USED IN CZECHOSLOVAKIA. Kukacka, R.; Zavada, M. (Krajske Station of Hygiene, Ostrava, Czech.). Cas. Lek. Cesk.; 108: 1321-3(24 Oct 1969). (In Czech.).

The output of various x-ray machines currently used in Czechoslovakia is reviewed. Reasons for the necessity of varying the exposure time when using different x-ray machines are discussed. The necessity of standardization in this field is stressed. (JPRS)

**17049** INVESTIGATION OF EXPOSURE TO IONIZING RADIATION DURING CATHETERIZATION OF THE HEART. Kukacka, R. (Krajske Station of Hygiene, Ostrava, Czech.). Cas. Lek. Cesk.; 108: 1251-5(10 Oct 1969). (In Czech).

Investigation conducted at two hospitals of Northern Moravia is discussed. The loads of ionizing radiation to which workers engaged in catheterization of the heart are exposed were determined by film dosimetry. The importance of proper shielding of the workers who are exposed to ionizing radiation discharged by the x-ray source used in making photographic pictures is stressed. Both the physician and the patient should be protected from this source of radiation. 2 Figures, 2 Tables, no references. (JPRS)

**17050** EVALUATION OF THE IRRADIATION HAZARD ASSOCIATED WITH THE USE OF ELECTRON TUBES. Makarova, L. A.; Volkova, N. I. Gig. Tr. Prof. Zabol.; 13: No. 2, 53-5(Feb 1969). (In Russian).

The possible risk of irradiation from electron tubes of the type used especially for oscillographs and television receivers is reviewed and research is presented. Results of measurements made in the proximity of different types of apparatus under normal operating conditions (tubes protected with shields) or under conditions encountered during repairs (tubes without shields) are tabulated. (TSS) (Occup. Safety and Health Abstr.)

**17051** RADIATION DOSE TO THE RESPIRATORY TRACT OF URANIUM MINERS: A REVIEW OF THE LITERATURE. Walsh, P. J. (National Inst. of Environmental Health Sciences, Research Triangle Park, N. C.). Environ. Res.; 3: 14-36(Jan 1970).

The literature on radiation dose to the respiratory tract of uranium miners due to inhalation of radon daughters is reviewed. The reasons for the different results obtained by various workers who have calculated dose are discussed and the dose is recalculated on the basis of presently available information. The relation between exposure in working level months and dose in rads is quantitated. The type of information needed for further improvements in dosage estimation is outlined. (auth)

**17052** X RADIOTHERAPY OF ACUTE INFLAMMATORY LESIONS IN THE SURGICAL PRACTICE. Evstigneeva, T. P.; Merman, A. M.; Krivoshei, V. M. (Inst. of Scientific-Research in Roentgen-Radiology, Moscow). Med. Radiol.; 12: No. 12, 13-17(Dec 1969). (In Russian).

Results concerning x-radiotherapy of 286 patients with acute inflammatory lesions are reported. The radiation dose to tissues treated by various x-ray procedures is defined more precisely and dosimetric substantiation for each localization of the inflammatory process is given. Less penetrating radiation in which adjacent tissues are subjected to a smaller dose is most expedient in the treatment of inflammation foci in soft tissues (in roentgenotherapy of post-operative infiltrates of the abdominal wall, anastomoses, and mastitis). In choosing physico-technical conditions for irradiation of inflammatory processes occurring in the vicinity of the bone tissue (for instance in paronychias, or thrombophlebites), it is expedient to use a generating potential of not below 180 to 200 kV, half-value layer of 0.97 to 1.1 mm Cu. Of a total of 286 patients, 132 were followed up after treatment over a period of up to 9 yrs with no complications due to x-radiotherapy. (auth)

**17053** EFFECT OF AIR CAVITIES ON THE ISODOSE OF TELECOBALT AND TELECESIUM BEAMS. Debois, Jean-M. (Hopital St-Norbert, Duffel, Belg.). Ann. Radiol.; 12: R869-74 (1969). (In French and English).

Except in the upper respiratory system, persistent air cavities are not found in the human body. Only in the head and neck region they have to be taken in account in planning radiation therapy. This problem was investigated in phantoms with small cavities measuring 1 to 3 cm either with circular, square, or rectangular cross-sections. Isodose curves were drawn for $^{60}Co$ and $^{137}Cs$ $\gamma$ beams. (C.H.)

## *Radiation Protection*

*Refer also to abstract 17134.*

**17054** (AECL-3475) THE CHALK RIVER NUCLEAR LABORATORIES PROTECTIVE CLOTHING PROGRAM. White, J. M. (Atomic Energy of Canada Ltd., Chalk River (Ontario). Chalk River Nuclear Labs.). Nov 1969. 17p. (CONF-690544-1). Dep. CFSTI (U. S. Sales Only). AECL $1.00.

From American Industrial Hygiene Meeting, Denver, Colo.

The selection and use of protective clothing at CRNL are based upon many years of experience. Supplementary work clothing is provided for those who work with radioactive materials. Such clothing usually consists of cotton shirts, trousers, coveralls, or sometimes only laboratory coats. In those buildings where there is high risk of contamination, gloves, underwear, socks, and special shoes are supplied. Plastic and other special clothing developed at CRNL to protect persons working with gross quantities of loose radioactive contamination are also briefly described. The different kinds of clothing, their selection and use, how they are handled and some of their limitations are discussed. (auth)

**17055** PROTECTION AGAINST RADIATION DURING RADIOLOGICAL DIAGNOSIS: THE PRESENT POSITION. Bagni, B.; Biolcati, A.; Nibbio, N. (Hospital of St. Anne, Ferrara, Italy. Univ., Ferrara, Italy). Minerva Radiol.; 14: 460-7(Oct 1969). (In Italian).

The damage likely to be incurred as a result of exposure to ionizing radiations for medical purposes is discussed and useful ways of restricting the dose absorbed during the course of radiological diagnosis are reported. (auth)

**17056** LYMPHOPOIESIS OF THYMUS OF IRRADIATED MICE. INTERCHANGE BETWEEN THYMOCYTES AND LYMPHOCYTES OF PROTECTED BONE MARROW. Gibertini, Giancarlo; Catalini, Nicola (Univ., Rome). Atti Accad. Naz. Lincei, Rend., Cl. Sci. Fis., Mat. Natur.; 46: 296-301(Mar 1969). (In Italian).

Lymphopoiesis in the thymus of irradiated mice was studied. One group of animals was whole-body irradiated and the other group received the same x ray dose (450 R) but had both the hind limbs lead-shielded. Differences were noted during both the degenerative and restitutional phase of the irradiated thymuses, as well as a different percentage of pycnotic lymphocytes. A migration of lymphocytes from the bone marrow to the thymus was suggested, since lymphocytes at different mitotic stages were observed as soon as 24 hr after irradiation in the cortical region of the thymus. (auth)

**17057** ROUTINE STUDY OF THE LUNG AS AFFECTED BY NEW X-RAY TECHNOLOGY. Seyss, R. Z. Tuberk; 127: 331-6 (Mar 1968). (In German).

Some advances in x-ray technology for routine lung studies that reduce patient exposure are discussed. Advantages of use of an image intensifier-television monitor combination that lowered doses to the patient included increased light sensitivity, decreased need for visual dark adaptation, use of lower voltages and current, and improved focussing of fields. Previous studies have indicated that the irradiation dose varied with age of patient and mW-sec dose administered. Using 65 to 75 KV irradiation, the irradiation dose was measured to be 5.7 R/min. Methods to decrease irradiation dose by use of an image intensifier-television combination include prefiltration and rotational fluoroscopy. Other important factors that reduced radiation doses were use of superhard radiation, exposure times of ~0.005 sec to avoid blurring of movement of the patient, and filtration of scattered irradiation. (BBB)

### *Safety Procedures*

*Refer also to abstract 17021.*

**17058** INORGANIC PHOSPHORUS OF RED BLOOD CORPUSCLES OF URANIUM MINE EMPLOYEES. Nosek, J.; Bartonova, H. (Uranium Industry Management, Pribram, Czech.). Cas. Lek. Cesk.; 108: 1263-4(10 Oct 1969). (In Czech).

Metabolism of mature red blood corpuscles is described. The increase of inorganic P compounds in starving mature red corpuscles is discussed. The increase of P in miners exposed to the atmosphere of uranium mines proved to be similar to that observed in controls. No differences were observed among the two groups. (JPRS)

### *Legal Aspects*

*Refer also to abstract 17048.*

## Medicine

*Refer also to abstracts 16610, 16791, and 18056.*

### *Protective Substances*

*Refer also to abstracts 16952, 16954, 17162, and 17163.*

**17059** INFLUENCE OF ADENOSINETRIPHOSPHORIC ACID ON THE HEMATOGENESIS OF IRRADIATED MICE. Marinenko, E. I.; Rogozkin, V. D.; Evseeva, N. K. (Inst. of Biophysics, Moscow). Radiobiologiya; 9: 801-5(Nov-Dec 1969). (In Russian).

The influence of the prophylactic administration of ATP (350 mg/kg) on the hematogenetic system of mice totally irradiated with the $\gamma$ rays of $^{60}Co$ at a dose of 650 R ($LD_{85/30}$) was studied. One of the means of realization of the radioprotective effect of ATP was its influence on processes of hematogenesis. When ATP was administered before irradiation, less development of destructive changes and a more rapid restoration of hematopoiesis were observed. (tr-auth)

**17060** EFFECTS OF CERTAIN RADIOPROTECTORS ON THE DYNAMICS OF THE b-WAVE OF THE ELECTRORETINOGRAM. Savchenko, B. N.; Kalmykova, G. I. (Leningrad State Univ.). Radiobiologiya; 9: 836-9(Nov-Dec 1969). (In Russian).

When certain radioprotectors are introduced into the lymphatic sac of frogs, a reversible decrease in the electroretinogram, induced by light or x rays, is observed. The injection of oxygen accelerates the restoration of the b-wave, suppressed by indolylalkylamines. It is proposed that the dynamics of the retinogram is an index of tissue hypoxia and may be evidence of the degree of protective action of the radioprotectors with a predominantly oxygen effect. (tr-auth)

**17061** INCREASED THERAPEUTIC EFFECTIVENESS OF SPLEEN TISSUE FROM IRRADIATED DONORS IN THE CASE OF TRANSPLANTATION TO LETHALLY IRRADIATED RECIPIENTS. Koval'chuk, L. V.; Petrov, R. V. (Inst. of Biophysics, Moscow). Radiobiologiya; 9: 840-5(Nov-Dec 1969). (In Russian).

Lethally irradiated CBA, $C_3H$, and $C_{57}B1$ mice were protected with spleen cells of CBA mice, intact or previously irradiated at a dose of 600 R 14 days before. It was found that to obtain the highest protective effect in syngenic and allogenic combinations, considerably fewer irradiated spleen cells than intact spleen cells were required. It is proposed that the increase in the protective properties of spleen tissue during the period of regeneration after sublethal irradiation is associated with a morphological reorganization of the organ and a substantial increase in the number of stem cells; during this period the spleen resembles the bone marrow in its morphological and functional properties. (tr-auth)

**17062** INFLUENCE OF AN ANTIHYPOXIC PREPARATION OF GUTIMINE ON THE RADIOPROTECTIVE EFFECT OF MEXAMINE, CYSTAPHOS, AND ANOXIC HYPOXIA. Zherebchenko, P. G.; Zaitseva, T. G.; Rachinskii, F. Yu. (Military-Medical Academy, Leningrad). Radiobiologiya; 9: 846-9(Nov-Dec 1969). (In Russian).

The influence of an antihypoxic preparation of gutimine (guanylthiourea) on the radioprotective action of mexamine (5-methoxytryptamine), cystaphos (monosodium salt of $\beta$-aminoethylthiophosphoric acid), anoxic hypoxia, as well as its influence on the toxicity of the radioprotectors, were investigated in experiments on mice. It was found that gutimine lowers the sensitivity of mice to anoxic hypoxia and mexamine. The toxicity of cystaphos is increased and the activity of the radioprotectors is unchanged, while anoxic hypoxia is even increased. The latter effect is explained by the presence of a slight but reproducible radioprotective effect for gutimine. (tr-auth)

**17063** COMPARATIVE EVALUATION OF THE TOXICITY AND RADIOPROTECTIVE ACTIVITY OF CERTAIN SULFUR-CONTAINING RADIOPROTECTORS. Yusipov, V. S.; Zherebchenko, P. G.; Slavachevskaya, N. M. (Military-Medical Academy, Leningrad). Radiobiologiya; 9: 850-3(Nov-Dec 1969). (In Russian).

A comparative study of the toxicity and radioprotective properties of cystamine, cystaphos, and certain salts of cystamine in the case of intraperitoneal and peroral administration, was conducted in experiments on mice. The most toxic substances, in the case of intraperitoneal injection, were cysteamine lactate and cysteamine hydrochloride, and in the case of peroral administration, cystaphos. The radioprotective action of the preparations was the same in the case of intraperitoneal administration. After peroral administration of the preparations at a dose of 4 mmoles/kg, the radioprotective activity of cystaphos was higher than that of the remaining substances. (tr-auth)

**17064** POSTRADIATION DECREASE IN THE DEATH RATE OF MICE BY GRAPE LIPOPOLYSACCHARIDES. Kuzin, A. M.; Kadzhayan, A. S. (Inst. of Biological Physics, Pushchino, USSR). Radiobiologiya; 9: 921-3(Nov-Dec 1969). (In Russian).

The influence of postradiation administration of lipopolysaccharides from the leaves and membranes of grapes on the death rate of mice was investigated. Male mice of the C57B1/6 line were irradiated on a GUPOS apparatus with the $\gamma$-rays of $^{137}Cs$ at a dose rate of 450 R/min and a dose of 700 R. Lipopolysaccharides were injected intraperitoneally three times in doses of 15 $\mu$g per mouse on the first, second, and fourth days after irradiation. The injection of lipopolysaccharides from the grape leaves and membranes reduces the death rate of the mice by ~40% owing to a decrease in the death rate peak on the 6th and 10th to 14th days after irradiation. (tr-auth)

**17065** INFLUENCE OF PROTECTORS ON THE ENTEROCHROMAFFIN SYSTEM OF INTACT AND IRRADIATED RATS. Pankratova, G. G.; Chernov, G. A. (Inst. of Biophysics, Moscow). Radiobiologiya; 9: 915-17(Nov-Dec 1969). (In Russian).

Mercamine in a radioprotective dose produced a decrease in the number of enterochromaffin cells in intact rats. Serotonin did not exhibit this action. The prophylactic administration of mercamine and serotonin prevented a change in the content of enterochromaffin cells in the intestines, characteristic of the height of radiation sickness, among irradiated rats. (tr-auth)

**17066** RADIOPROTECTIVE EFFECTS OF $\beta$-MERCAPTOETHYLAMINE HYDROTARTRATE IN ACUTE RADIATION SICKNESS IN DOGS. Tikhomirova, M. V.; Yakovlev, V. G.; Isupova, L. S.; Klimova, R. A. (Inst. of Biophysics, Moscow). Radiobiologiya; 9: 854-8(Nov-Dec 1969). (In Russian).

A high radioprotective effect in the case of intravenous injection of $\beta$-mercaptoethylamine hydrotartrate was established in experiments on dogs. The preparation prevents death of the dogs from acute radiation sickness, promotes an easier course of the

disease and less inhibition of hematogenesis, as well as a normalization of the system of SH-groups and smaller fluctuations in the copper content in the blood of the irradiated dogs. (tr-auth)

**17067** THE RELATION BETWEEN THE MITOGENIC AND THERAPEUTIC ACTIONS OF MILK AND SODIUM CASEINATE IN X-IRRADIATED MICE. Rixon, R. H.; Whitfield, J. F. (National Research Council of Canada, Ottawa). Radiat. Res.; 40: 601-12(Dec 1969).

A single I. P. injection of evaporated bovine milk or sodium caseinate into mice immediately after a whole body exposure to 600 R of x rays increased the 30-day survival from 45 to 73 and 80%, respectively. These substances also doubled the mitotic activity of bone marrow in nonirradiated and irradiated (300 R) mice within 6 hours of injection. In contrast, a single intraperitoneal injection of calcium caseinate and bovine parathyroid extract (given subcutaneously) were without effect on either the mitotic activity of bone marrow or the level of radiation mortality. The bovine parathyroid hormone did not affect the levels of the total or free calcium in the blood, while milk and calcium caseinate increased the total calcium concentration, but did not affect the concentration of physiologically active free calcium. Sodium caseinate, on the other hand, transiently lowered the levels of both the total and the free calcium. Evidence is presented which suggests that a hypocalcemia-induced release of endogenous parathyroid hormone is responsible for the mitogenic and therapeutic activities of sodium caseinate. The mechanism of action of milk is not known. The mitogenic and therapeutic actions of milk and sodium caseinate support the concept that the postirradiation stimulation of cell proliferation in hematopoietic tissues can play an important role in reducing radiation lethality. (auth)

**17068** LATE EFFECTS OF X-IRRADIATION IN CHEMICALLY PROTECTED MICE: ALTERATION OF TUMOR INCIDENCE AFTER AET-TREATMENT. Davis, William E. Jr.; Cole, Leonard J.; Nowell, Peter C. (Naval Radiological Defense Lab., San Francisco. Univ. of Pennsylvania, Philadelphia). Radiat. Res.; 41: 400-08(Feb 1970).

Female mice ($LAF_1J$) were treated at age 14 weeks to 250, 500, or 880 Rads of x irradiation. Several of the groups were injected with AET just prior to irradiation, and some groups were transfused with isogenic marrow cells after exposure to 880 Rads. The mice were then observed for periods up to 140 weeks for gross signs of neoplasms or illness, at which time they were sacrificed. It was found that the lymphoma incidence decreased from normal levels after exposure to the higher radiation doses, but that AET tended to inhibit this therapeutic radiation effect. On the other hand, the incidence of hepatomas and nonlymphatic malignancies increased with doses up to 500 Rads. This carcinogenic radiation effect was inhibited by AET injection. In the mice exposed to 880 Rads and restored with marrow cells, none showed these lesions in contrast to those that were treated with AET. While the results are not definitive, they do indicate that x radiation acts primarily as a carcinogen for some tumors at lower doses, but at higher doses it acts as a sterilizing agent by proliferative killing of cells. The radioprotective compound, AET, which reduces the effective doses to the tissues, tends to shift the resultant of these two effects such that the carcinogenic effect after 500 Rads and the therapeutic effect after 880 Rads are reversed. (auth)

**17069** EFFECT OF RADIATION-SENSITIZING AGENTS IN RADIATION THERAPY OF MOUSE MAMMARY CARCINOMA. Suit, Herman D.; Hewitt, Roger; Urano, Muneyasu (Univ. of Texas, Houston). Radiology; 94: 189-95(Jan 1970).

5-Iodo-2'-Deoxyuridine (IUDR), injected intraperitoneally, did not cause cell death for tumor cells proliferating as small colonies in subcutaneous tissues. Only a small amount of thymidine (TdR) of total DNA was replaced. A small fraction of the cells seemed to be in active cell proliferation, and they efficiently utilized the injected IUdR. At completion of the injections, nearly all cells in the aerobic and hypoxic compartments that are viable have been through at least one S period in the preceding 48 hr. (auth)

## *Radiation Sickness and Injuries*

**17070** TRANSPLANTATION OF BONE MARROW INTO IRRADIATED PRIMATES. Chertkov, I. L.; Sukyasyan, G. V.; Novikova, M. N.; (and others) (Myelo-Hemotherapeutic Lab. of Acute Radiation Sickness, Moscow. Central Inst. of Hematology and Blood Transfusion, Moscow. Inst. for Experimental Pathology and Therapy, Moscow). Probl. Gematol. Pereliv. Krovi; 14: 36-47(Oct 1969). (In Russian).

It has been found during earlier studies that transplantation of autologous bone marrow into macaque monkeys exposed to doses up to 1000 R is highly effective as a therapeutic tool while allogenic bone marrow induces an acute secondary sickness, resulting in the death of the animals. The histogenesis of transplanted hemogenic tissue was further studied on 26 hamadryas baboons of both sexes. Four animals were used for the study of the rejection of allogenic skin and the antibody formation in response to the introduction of the Vi antigen of typhoid fever bacteria from unirradiated animals. Additional 19 animals were exposed to doses ranging from 900 to 1100 R, using 5 for control purposes, 8 for the transplantation of autologous and 6 for that of allogenic bone marrow; three animals were used as donor for the allogenic bone marrow. The results indicated that transplantation of hemogenic tissue in baboons is similar to similar operations in dogs and macaque monkeys, being different from that in rodents. These animals require much more tissue than rodents to obtain a protective effect. Allogenic transplantation in primates causes acute secondary radiation sickness, resulting from the lymphoid transformation of the transplant. This confirms that the chief obstacle against the clinical use of allogenic bone marrow into irradiated persons is the typical transplant versus host reaction. (TTT)

## *Radiodiagnosis*

*Refer also to abstracts 16812, 16850, 16867, 16868, 16871, 17045, 17046, 17057, and 17157.*

**17071** (COO-1472-26) RADIOISOTOPE INVENTORY PROGRAM. Groome, David S. (Colorado Univ., Denver. Medical Center. Datametrics, Inc., Boulder, Colo.). Dec 1969. 15p. Dep. CFSTI.

Nuclear medicine is unique in that the pharmaceuticals stocked in the laboratory's inventory are constantly being depleted by radioisotope decay whether any of the material is used or not. This presents an unusual problem in inventory control, and one particularly suited for the use of a digital computer. A set of programs was developed for a process control computer which completely control a radioisotope inventory. The computer operates in the "multiprogramming" mode, allowing several programs to be executed concurrently. The programs are logically divided into four sections. The first lists all of the shipments currently in the inventory with both the initial and current activity and volume. Current data are reported to the present day and hour. This allows the technician to quickly note isotopes for which the total activity available requires reordering and it allows easy analysis since all information is presented on a single page. The second program allows the technician to log shipments in and out of the inventory system. When a shipment is logged out, the computer produces a listing of each patient that received a portion of the isotope shipment and the date and activity received. This information may then be permanently filed both in the patient's chart and the isotope record file. To calculate a dose, the technician need only enter the isotope and the dose required and the patient's weight and hospital number. The program first determines if there is enough isotope available. If not, the total amount available is printed. If the total dose is available, the computer informs the technician of the shipment and volume to use. The physician need only check that the dose requested is correct. After the dose is drawn and given, the technician uses the fourth program to inform the computer that the last dose calculated has been used. The inventory files are then automatically updated. This system of radioisotope inventory control alleviates the need of the technician making and recording repetitive decay calculations and ensures that the calculations will be error free. Additionally, records of each calculation and the isotope usage are maintained in printed form. (auth)

**17072** (COO-1472-27) [DIGITAL COMPUTER ANALYSIS AND DISPLAY OF THE RADIOISOTOPE SCAN]. Technical Progress Report. (Colorado Univ., Denver. Medical Center). [1969]. Contract AT(11-1)-1472. 27p. Dep. CFSTI.

A computer program for performing two dimensional Fast Fourier Transforms of radioisotope scans and carrying out the inversion of the transforms was developed. Methods of using these transforms to accomplish differential and band pass filtering of scans and to enhance scan resolution by deconvolution with a collimator response function were developed. Evaluation of the results of applying these procedures to scans of phantoms and patients' organs is reported. Methods developed for digital computer analyses and display of radioisotope scans are described. (C.H.)

**17073** DETERMINATION OF KVP OF DIAGNOSTIC X-RAY GENERATORS. Hale, John; Bloch, Peter (Univ. of Pennsylvania, Philadelphia). Phys. Med. Biol.; 15: 123-4(Jan 1970).

Using a diagnostic x-ray equipment at potentials up to 115 kVp it was shown that the kV of the machine could be detected by measuring the x-ray beam transmitted through an absorber. (UK)

17074 RESULTS OF ANGIOGRAPHY AND BRAIN SCANNING FOLLOWING BRAIN INFARCTIONS. Marx, P.; Rosarius, C. (Max-Planck-Institut fuer Hirnforschung, Cologne). Radiologe; 9: 428-31(Nov 1969). (In German).

Results of brain scans on patients manifesting early changes following brain infarction are reported. In 9 out of 33 patients with an infarct in the area of the internal carotid artery a positive brain scan was found. Two of these patients showed a hyperemic focus in a corresponding area, two others showed distinct signs of focal ischemia. The results indicate that the cause of positive brain scans may be due not only to damage of the blood-brain-barrier but also may result from focal hyperemia. (auth)

17075 STUDIES OF CEREBRAL BLOOD FLOW WITH RADIOACTIVE ISOTOPES. Hacker, H. (Johann Wolfgang Goethe-Univ., Frankfurt am Main). Radiologe; 9: 407-14(Nov 1969). (In German).

Various methods for measuring cerebral blood flow are reviewed. Increasingly, isotope procedures gain importance in clinical procedures. 32 references are given. (H.B.G.)

17076 RARE ETIOLOGY AND ANGIOGRAPHY OF A CEREBRAL INFARCTION IN CHILDHOOD. Hammer, B. (Wagner-Jauregg-Krankenhauses des Landes Oberoesterreich, Linz, Ger.). Radiologe; 9: 418-21(Nov 1969). (In German).

In a previously healthy seven year old girl, complete rightsided hemiparesis developed within a few minutes. Angiography showed occlusion of the interior and medial cerebral arteries. Scintigraphy with technetium-99 showed increased activity in the region of the infarction. Serological examinations led to the diagnosis of localized periarteritis nodosa. Treatment consisted of a combination of cortisone and penicillin, which led to considerable improvement. (H.B.G.)

17077 PROGRESS IN TUMOR DIAGNOSTICS BY USING NUCLEAR-MEDICAL TECHNIQUES. Morczek, A. (Medizinische Akademie, Magdeburg, Ger.). Isotopenpraxis; 5: 351-5(Sep-Oct 1969). (In German).

The most important nuclear-medical techniques introduced in clinical practice for the diagnostics of tumour diseases are discussed in the light of the principles of their application and clinical indications. In summary, it is established that the uses of radioactive nuclides have decisively contributed to the development of tumour diagnostics in various organs and that certain tumours are detectable by them only. Thus it is, first of all, the bearing technique in diagnostics of brain tumours. In various other methods it is an essential addition. (auth)

17078 MALIGNANT TUMOURS IN OTORHINOLARYNGOLOGY. I. TUMOURS OF THE EPIPHARYNX. Kup, W.; Lange, D. (Hals-Nasen-Ohrenklinik im Staedtische Klinikum, Berlin). Arch. Geschwulstforsch.; 34: 62-86(1969). (In German).

In Europe malignant growths of the nasopharynx are very rare. Important signs are swelling of the cervical glands and complaints on ear and nose. The otoneurologic signs demonstrate an advanced stage. Diagnosis is affirmed by biopsy and specially x-ray examinations. Today radiotherapy is decisive, surgery is only an added act in some cases. About the cervical metastases therapy the comprehensions are different. The prognosis is bad, we see permanent cures only between 15 and 30%. It seems that with the propagation of the modern radiotherapy the number of healed patients is increasing. (auth)

17079 ACTUALITY IN THE SUBJECT OF PROTECTION AGAINST IONIZING RADIATION. Lura, A.; Alberti, G. P.; Palmieri, G. C.; Voltolini, G. (Univ., Ferrara, Italy). Minerva Med., 60: 1501-3(Apr. 18, 1969). (In Italian).

The use of photographic equipment of the polaroid type is suggested for radiography during operations as experimental results have shown that the radiation dose is much less and that as much radiological data are obtained as by conventional radiographic methods. Examples are given of the use of polaroid-type equipment to illustrate its usefulness and scope of utility. (J.S.R.)

17080 SCINTILLATION CAMERA IN THE EVALUATION OF RENAL TRANSPLANTS. Weiss, Edward R.; Blahd, William H.; Winston, Martin A.; Hartenbower, David L.; Koppel, Marcel; Thomas, Panchita B. (Wadsworth Hospital, Los Angeles). J. Nucl. Med.; 11: 69-77(Feb 1970).

Twenty-three renal transplant patients underwent a series of post-transplant renal evaluations. Serial $^{99m}$Tc-pertechnetate scintiphotos were visually analyzed for abnormalities of transplant vascular perfusion, while serial $^{131}$I-Hippuran scintiphotos were used to evaluate transplant function and morphology as well as the excretory progression of the tracer from the renal cortex to the renal pelvis and ultimately to the urinary bladder. In both tracer techniques, a gamma scintillation camera was used with a 3-in. multichannel collimator. A 4,000-hole collimator was used for the technetium and a 1,000-hole collimator for the higher energy gamma of iodine. Accuracy and reproducibility of these techniques for studying the various pathological states that affect transplanted kidneys were excellent. The findings of the scintillation camera radioisotope studies, which are summarized in tabular form, correlated well with the patient's clinical course and were often more sensitive than conventional methods for transplant evaluation. (E.R.B.)

17081 COMBINED SUPERIOR VENA CAVA OBSTRUCTION AND PERICARDIAL EFFUSION DEMONSTRATED BY RADIOISOTOPIC ANGIOCARDIOGRAPHY. Matin, Philip; Ray, Gordon; Kriss, Joseph P. (Stanford Univ. School of Medicine, Palo Alto, Calif.). J. Nucl. Med.; 11: 78-80(Feb 1970).

A variable time-lapse videoscintiscope (VTV), consisting of a scintillation camera modified by the addition of accessories permitting the recording of the oscilloscopic display of the camera on tape and then the generation of images integrated over any desired time interval following injection of the radiopharmaceutical, was used to evaluate a patient with Hodgkin's disease who had both superior vena cava obstruction and pericardial effusion. Chest x ray revealed a left pleural effusion and a questionable pericardial effusion, but no mediastinal mass was noted. Angiocardiography using $^{99m}$Tc-pertechnetate, however, not only demonstrated the pericardial effusion, but also showed the obstruction of the superior vena cava as well as evidence of marked collateral circulation. The advantages of radioisotopic angiocardiography in this and in similar cases include: requires only intravenous injection; requires only a few minutes to perform; can be performed on ambulatory or hospitalized patients; can be performed in the erect, semirecumbent, or supine positions; is associated with no drug toxicity; results in a very low body radiation dose (about 0.1 rad); uses generally available pharmaceuticals; can be repeated frequently to follow the course of the disease or the efficacy of treatment; and provides anatomic and hemodynamic information regarding the site of obstruction and the extent and location of collateral circulation. (E.R.B.)

17082 ESTIMATION OF RESIDUAL URINE AND URINE FLOW RATES WITHOUT URETHRAL CATHETERIZATION. Strauss, Bernard S.; Blaufox, M. Donald (Albert Einstein Coll. of Medicine, Bronx, N. Y.). J. Nucl. Med.; 11: 81-4(Feb 1970).

Thirty patients (20 with obstructive uropathy and 10 normal) were studied to evaluate the use of radionuclides for the estimation of residual urine and urine flow rates without urethral catheterization. The residual urine was estimated from the radioactivity detected in the bladder area 45 min or longer after the intravenous injection of $^{131}$I-orthoiodohippurate. The mean residual volume determined in 20 patients with obstructive uropathy by the isotopic method was 77 ± 17 ml (s.e.). Catheterization performed immediately after the isotope study revealed a residual of 80 ± 18 ml (s.e.). This difference is not significant ($0.3 < p < 0.4$). None of the 10 normal subjects had a significant residual by the isotopic method; they were not catheterized. The mean urine flow rate in the normal subjects was 16.1 ml/sec ± 8.3 (s.d.) and 5.9 ml/sec ± 3.3 (s.d.) in the abnormal patients ($p < 0.01$). The method described is accurate and reliable and should be used in preference to urethral catheterization to determine residual urine volume and urine flow rates in patients with lower urinary tract obstruction. (auth)

17083 COMPARTMENTAL REDISTRIBUTION OF $^{99m}$Tc-PERTECHNETATE IN THE PRESENCE OF PERCHLORATE ION AND ITS RELATION TO PLASMA PROTEIN BINDING. Oldendorf, William H.; Sisson, Warden B.; Iisaka, Youichi (Wadsworth Hospital, Los Angeles. Univ. of California, Los Angeles). J. Nucl. Med.; 11: 85-8(Feb 1970).

It was shown in rabbits that the addition of 3 mg/kg of perchlorate ($ClO_4^-$) ion results in a major tissue redistribution of pertechnetate ($TcO_4^-$). This probably results from release to $TcO_4^-$ from plasma protein binding sites with resulting redistribution to tissue extracellular spaces and a shift of a portion of the $TcO_4^-$ intracellularly. The injection of this dose of $ClO_4^-$ results in tissue levels relative to blood plasma about 1.38 times greater than without $ClO_4^-$. In the presence of $ClO_4^-$, $TcO_4^-$ moves from plasma into red cells. The $ClO_4^-$ dose dependence of this plasma-to-red cell shift was studied in vivo. The ratio of plasma-to-red cell concentration of $TcO_4^-$ shifts from 3.98 ± 0.31 without $ClO_4^-$ to 1.98 ± 0.32 with 3 mg/kg of $ClO_4^-$. This intracellular shift was demonstrated in vitro at a single high concentration of $ClO_4^-$ producing a ratio of 1.25. The effect of $ClO_4^-$ on plasma-to-red cell distribution is complete within 1 min of i.v. injection in the rabbit. Chloride does not redistribute between red cells and plasma as does $TcO_4^-$ in response to $ClO_4^-$. Preliminary dialysis studies indicate about 80% of plasma $TcO_4^-$ is protein bound in rabbit and

man. This drops to about 40% in the presence of $ClO_4^-$ concentrations used in this study in the rabbit but changes very little in man. The tissue compartmental redistribution in the presence of $ClO_4^-$ described here is not expected to produce visible changes in clinical scan appearance except in those organs where active uptake is present. Possible mechanisms responsible for this redistribution are discussed. (auth)

**17084** ABNORMAL BRAIN SCAN IN EOSINOPHILIC GRANULOMA OF THE SKULL. Benua, Richard S. (Univ. of Texas, Galveston). J. Nucl. Med.; 11: 89-91(Feb 1970).

An eosinophilic granuloma of the cranial vault was visualized in a $^{197}$Hg-chlormerodrin brain scan. After 42 months the patient returned with another granuloma of the parietal bone which was visualized on a $^{99m}$Tc-pertechnetate brain scan. Erosion of the right parietal bone was apparent on the roentgenogram at each examination. (auth)

**17085** MALIGNANT LYMPHOMA DEMONSTRATED WITH $^{75}$Se-SELENOMETHIONINE AND SELECTIVE INTRA-ARTERIAL INJECTION OF $^{131}$I-MACROAGGREGATED HUMAN SERUM ALBUMIN. Ashburn, William L.; McDonald, Daniel G. (University Hospital of San Diego County, Calif.). J. Nucl. Med.; 11: 92-4 (Feb 1970).

A case of malignant abdominal lymphoma is presented that was tentatively diagnosed with intravenous $^{75}$Se-selenomethionine and $^{131}$I-MAA selectively injected intra-arterially. The value of these radioisotopic studies in evaluating such patients preoperatively is suggested. A second, similar case is discussed briefly. (auth)

**17086** DETERMINATION OF INTRARENAL BLOOD FLOW IN NORMAL KIDNEYS AND IN AUTOTRANSPLANTED ORGANS, BY MEANS OF RADIOACTIVE XENON $^{133}$Xe. Graban, Wieslaw; Rowinski, Wojciech; Dura-Kubas, Irmina; Skoskiewicz, Marek. Pol. Przegl. Radiol. Med. Nukl.; 33: 699-708(Sep-Oct 1969). (In Polish).

Xenon-133 was used to determine intrarenal blood flow through normal and autotransplanted organs in dogs. The radioactivity decrease curves were recorded over the kidneys and transferred on logarithmic scales and analyzed. The three curve components obtained permitted determination of the blood flow in ml/min/100 g and the per cent participation in the activity of the renal cortex, cortico-medullar area and the internal part of the renal medulla. The flow values measured in the individual anatomical parts of the kidney were similar in the normal kidney and in the transplanted organ. A marked rise of the percentage of activity was noted in the II and III component with a concomitant decrease of the flow rate in component I in the experimental group with various complications (bleeding, incipient renal artery thrombosis, etc.). (auth)

**17087** $^{131}$Ba: AN INTERMEDIATE-LIVED RADIONUCLIDE FOR BONE SCANNING. Spencer, Richard P.; Lange, Robert C.; Treves, Salvador (Yale Univ., New Haven). J. Nucl. Med.; 11: 95-6(Feb 1970).

The use of $^{131}$Ba, an intermediate-lived bone-seeking agent, as a bone-scanning substance is reported. In comparison with the commonly used bone-scanning agent $^{85}$Sr, $^{131}$Ba has a shorter half-life, a lower equilibrium absorbed dose, and lower energy emissions (for greater detector efficiency). Short-lived $^{87m}$Sr is expensive and has certain inherent difficulties, and the very short half-life of $^{18}$F precludes distribution at a distance from the production site and the possibility of late scans. Production of $^{131}$Ba can be accomplished using a nuclear reactor, by the $^{130}$Ba(n,$\gamma$)$^{131}$Ba reaction, or a cyclotron, by the $^{133}$Cs(p,3n)$^{131}$Ba interaction. (E.R.B.)

**17088** ON CONTRASTING OF THE THORACIC DUCT AND DISTAL LYMPH NODES IN LOWER LYMPHOGRAPHY. Ivanova, O. I.; Kleinman, D. L.; Kozhevnikov, S. Yu.; Levitskaya, N. A. (Research Inst. of Oncology, Leningrad). Vop. Onkol.; 15: No. 12, 35-9(1969). (In Russian).

The possibility of contrasting the thoracic duct and distal lymph nodes in lower-body lymphography using a mixture of iodolipol and ether was investigated. It proved to be unfeasible to obtain a roentgenographic picture of the thoracic duct over its whole extension. (auth)

**17089** RADIOISOTOPE SCANNING IN DIAGNOSIS OF RENAL TUMORS. Klyucharev, B. V.; Kuz'min, V. G.; Osipov, I. S.; Chupin, I. Ya. (Central Research Inst. of Radiology and Roentgenology, Leningrad. Research Inst. of Oncology, Leningrad). Vop. Onkol.; 15: No. 12, 21-6(1969). (In Russian).

Thirty patients with diagnosis of the kidney tumor were investigated using radioisotope scanning and radiographic methods. In 22 cases the results of scanning completely coincided with roentgenological findings, in four patients they did not coincide at all. Radioisotope scanning was of great importance in the complex diagnostic investigations in patients suspected of kidney tumor. (auth)

**17090** CRITICAL STUDY OF THE TECHNIQUE OF MEASURING CIRCULATORY OUTPUT BY $^{85}$Kr. Malherbe, F.; Klaurens, C.; Amstutz, Ph. (Hopital Claude-Bernard, Paris). Rev. Fr. Etud. Clin. Biol.; 14: 932-7(Nov 1969). (In French).

Measurement of blood flow by the $^{85}$Kr technique requires certain technical precautions to be observed in order to achieve a satisfactory result. The present critical study emphasizes some of the technical considerations concerned with the injection of the tracer. The methods of taking and counting the radioactive samples are also discussed. (auth)

**17091** SCANNING OF THE SPLEEN IN THE DIAGNOSIS OF LYMPHOGRANULOMATOSIS. Kulikova, M. M. (Inst. of Medical Radiology, Obninsk, USSR). Vop. Onkol.; 15: No. 12, 15-20(1969). (In Russian).

The results of radioisotope scanning in 87 patients with various stages of lymphogranuloma are presented. $^{51}$Cr or $^{99m}$Tc labeled erythrocytes treated thermally and labeled with $^{51}$Cr or $^{99m}$Tc were used. It was demonstrated that in the initial stages (I and II) of lymphogranuloma splenic involvement, usually not diagnosed by the routine clinical methods, was determined in 70 percent. The percent of detection of the splenic involvement in all stages by radioisotope scanning was three times greater than in clinical studies. For estimation of the organ size a splenic index was used. (auth)

**17092** URINE RETENTION IN THE URINARY BLADDER IN CHILDREN. Boron, Zdzislaw; Balcar-Boron, Anna. Pol. Przegl. Radiol. Med. Nukl.; 33: 677-81(Sep-Oct 1969). (In Polish).

The clinical role of urine retention in children is discussed and a simple radiological technique of urine residue detection in the bladder is proposed. (auth)

**17093** PARASITIC TUMOR OF THE IV VENTRICLE WITH ATYPICAL CLINICAL COURSE DIAGNOSED BY MEANS OF POSITIVE VENTRICULOGRAPHY. Imielinski, Leslaw B.; Drewniak, Kazimierz; Billewicz, Olgierd. Pol. Przegl. Radiol. Med. Nukl.; 33: 585-90(Sep-Oct 1969). (In Polish).

A case of cysticercosis in a 41-year-old woman is presented localized in the IV ventricle. The diagnosis was based on ventriculography with the application of oily contrast medium. The patient underwent surgical intervention which confirmed the diagnosis. (auth)

**17094** RADIOLOGICAL DIAGNOSIS OF PEPTIC ULCER IN THE SMALL BOWEL. Kulicz, Adam. Pol. Przegl. Radiol. Med. Nukl.; 33: 625-31(Sep-Oct 1969). (In Polish).

The radiological diagnostic problems of small bowel peptic ulcer are discussed based on observation of 31 cases. The patients were men in 28 cases and women in three cases. In 27 subjects the peptic ulcer developed after partial resection of the ventricle and in four cases after gastro-jejunostomy. Proper diagnosis on the radiological basis was given in 23 cases (74%), while in eight cases the result of examination was negative (26%). Such low detectability of this type of peptic ulcerations is caused by the jejunal anatomical conditions, small dimensions of ulceration, and postoperative changes of the small bowel patterns. (auth)

**17095** RADIOLYMPHOGRAPHY WITH THE APPLICATION OF $^{131}$I. PART I. TECHNICAL CONSIDERATIONS. Skalska-Vorbrodt, Janina; Hliniakowa, Irena; Godawski, Jerzy. Pol. Przegl. Radiol. Med. Nukl.; 33: 709-14(Sep-Oct 1969). (In Polish).

Techniques for lymph node scanning using iodine-131-labeled lipiodol are described. The minor risk of irradiation for the staff and good tolerance by the patients are stressed. The applied dose of $^{131}$I ranged to $\mu$C levels and gave highly selective visualization of the lymph nodes. (auth)

**17096** USEFULNESS OF THE MEASUREMENT OF THE MUSCLE BLOOD FLOW IN THE EXTREMITIES USING $^{133}$Xe. Galus, K. (Medical Academy, Warsaw). Pol. Med. J.; 8: 1069-77(1969).

Resting and maximal muscle blood flow was measured in the lower extremities of healthy subjects and patients with obliterating arterial diseases, using $^{133}$Xe scanning. Differences were studied between healthy subjects and patients with arterial diseases, as regards the rate of decrease in the maximal muscle blood flow. The reproducibility of the maximum flow measurements was evaluated. (auth)

**17097** RELATIVE DIAGNOSTIC VALUE OF RADIOLOGIC AND ISOTOPIC METHODS ASSOCIATED WITH CYSTOMETRY

IN IMPROVEMENT OF THE VESICO-URETERO-RENAL REFLUX. Collard, M. (Hopital de Baviere, Liege); Timmermans, L.; Merchie, G. J. Belge Radiol.; 52: 327-34(Nov-Dec 1969). (In French).

Data are reported on 179 cases of vesicoureteral reflux studied with the aid of radiological, radiological techniques associated with registrations of the intracavitary pressure, or radioisotope scanning. Until now, the radiological technique combining cystomanometry with radiological findings was the most satisfactory method for detection and characterization of vesicouretero-renal reflux. The isotope methods have not, until now, acquired the refinements of radiological techniques; however, the registration of cystomanometric curves of intracavitary pressures, together with the radioisotope scan is considered to be a very promising, method. (auth)

17098 DESCENDING PYELO-URETEROGRAPHY THROUGH TRANSCUTANEOUS PUNCTION OF THE RENAL PELVIS. Rajszys, Ryszard; Pruszynski, Bogdan. Pol. Przegl. Radiol. Med. Nukl.; 33: 783-8(1969). (In Polish).

The technique of percutaneous puncture of the renal pelvis in order to perform descending pyelo-ureterography is described. The value of the technique is illustrated by two selected cases. (auth)

17099 ASSESSMENT OF REGIONAL LUNG FUNCTION AND ITS CLINICAL APPLICATIONS BY THE COMBINED USE OF LUNG SCAN AND GAMMA DENSIGRAPHY. Zelefsky, Melvin N.; Schulz, Robert J.; Freeman, Leonard M. (Albert Einstein Coll. of Medicine, Bronx, N. Y.). Radiology; 94: 167-74(Jan 1970).

A combination of lung scanning for evaluation of perfusion and gamma densigraphy for evaluation of regional ventilation was successfully applied in a variety of clinical situations. The technique involved the use of an external $^{241}$Am source to measure changes of linear radiodensity of the chest with respiration. This combined diagnostic approach was employed to study patients with pulmonary embolism, emphysema, tuberculosis, and cancer. (auth)

17100 $^{111}$In FOR IMAGING: LYMPH NODE VISUALIZATION. Goodwin, D. A. (Veterans Administration Hospital, Palo Alto, Calif. Stanford Univ., Palo Alto, Calif.); Finston, R. A.; Colombetti, L. G.; Beaver, J. E.; Hupf, H. Radiology; 94: 175-8(Jan 1970).

A new radiocolloid of $^{111}$In has optimum physical characteristics for the study of lymphatics using the Anger gamma camera. For observations one to three days following injection, the half-life of $^{111}$In allows excellent counting statistics with minimum patient radiation dose. Indium-111 was injected subcutaneously in the dog and was distributed primarily in the injection site, regional lymph nodes, and the liver by way of the systemic veins. Following intravenous injection in white mice, $^{111}$In was concentrated in the liver and spleen, and virtually no activity was recovered from the blood, kidneys, or lungs. (auth)

17101 $^{35}$S MEASUREMENTS OF FUNCTIONAL AND TOTAL EXTRACELLULAR FLUID IN DOGS WITH HEMORRHAGIC SHOCK. Mathews, Raymond E.; Douglas, Gary J. (Toronto Western Hospital). Surg. Forum; 20: 3-5(1969).

From 55th Annual Clinical Congress, San Francisco, Calif. See CONF-691028-(Absts).

Results of studies on the distribution of intravenously injected $^{35}$S in dogs showed that extracellular fluid has rapid and slow, or functional and total, equilibrating components. Analysis of the entire $^{35}$S distribution curve allows separation and measurement of each component. In the normal dog the ratio of functional to total extracellular fluid volume is constant. Under circumstances where fluid is sequestered such as in ascites, the volume can be detected and measured by this technique. (auth)

17102 EVALUATION OF RADIOSULFATE AS A MEASURE OF FUNCTIONAL AND TOTAL EXTRACELLULAR FLUID. Douglas, Gary J.; Shklar, Jerry O.; Forstner, Gordon G.; Mathews, Raymond E. (Toronto Western Hospital). Surg. Forum; 20: 34-6(1969).

From 55th Annual Clinical Congress, San Francisco, Calif. See CONF-691028-(Absts.).

Sulfur-35 is an effective tracer for measuring extracellular fluid in normal dogs and dogs in hemorrhagic shock, as the functional and total volumes can be measured individually. Hemorrhagic shock can result in a deficit in one or both components, depending on the severity. Adequate treatment of severe shock requires the administration of both blood and a salt solution. Volume calculation from a single 20-min sample of blood plasma appears adequate for measuring the functional volume, although calculation from the rapid slope is preferable. (auth)

17103 RADIOACTIVE DETECTION OF EXPERIMENTAL ABSCESSES. Robinson, Richard G.; Wilder, Joseph R.; Deysine, Maximo (Hospital for Joint Diseases and Medical Center, New York). Surg. Forum; 20: 58-60(1969).

From 55th Annual Clinical Congress, San Francisco, Calif. See CONF-691028-(Absts.).

A method to detect experimental abscesses by scanning using $^{51}$Cr labeled autologous leukocytes is described. The potential of this method for diagnosis in human beings is emphasized. (auth)

17104 TISSUE DISTRIBUTION OF RADIOSULFATE TOLUIDINE BLUE. Lindenauer, S. Martin; Schultz, Jerome S.; Self, William; DiGiulio, Walter (Univ. of Michigan, Ann Arbor. Veterans Administration Hospital, Ann Arbor, Mich.). Surg. Forum; 20: 78-80(1969).

From 55th Annual Clinical Congress, San Francisco, Calif. See CONF-691028-(Absts.).

Results of studies in dogs indicated that sulfur-35-labeled toluidine blue can be used as an agent for parathyroid scinti-scanning. The similar concentrations of toluidine blue in liver and pancreas make pancreatic scanning unlikely. The results in dogs are similar to visual and colorimetric observations in man. The slow infusion of low doses of toluidine blue can be utilized effectively in visually identifying parathyroid tissue during surgery. (auth)

17105 VALIDITY OF CONCEPT OF INCREASED EXTRACELLULAR FLUID AFTER OPEN HEART SURGERY. Breckenridge, Iain M.; Digerness, Stanley B.; Kirklin, John W. (Medical College of Alabama, Birmingham. Veterans's Administration Hospital, Birmingham, Ala.). Surg. Forum; 20: 169-71(1969).

From 55th Annual Clinical Congress, San Francisco, Calif. See CONF-691028-(Absts.).

Several studies have indicated that the volume of extracellular fluid (ECF) is usually larger 24 hr after open intracardiac operation than before. Calculations which have been made of changes in the volume of intracellular water and concentration of intracellular electrolytes depend on accurate measurement of ECF. Results are reported from measurements of extracellular fluid volume in patients before and after open heart surgery using $^{82}$Br and inulin as tracers. It was concluded that it is highly likely that ECF is increased for several days after intracardiac surgery. The true magnitude of the increase is uncertain and probably cannot be determined by indicator dilution methods. (C.H.)

17106 $^{85}$Sr SCINTIMETRY IN THE STUDY OF SKELETAL COMPLICATIONS OF RENAL TRANSPLANTATION. Crutchlow, William P.; David, David S. (New York Hospital). Surg. Forum; 20: 458-60(1969).

From 55th Annual Clinical Congress, San Francisco, Calif. See CONF-691028-(Absts.).

Thirteen of 34 patients developed arthralgia after kidney transplantation. Two of these 13 individuals had multifocal osteonecrosis evident on radiographs when first seen. Strontium-85 scanning demonstrated no new foci in these patients and was normal in five others. One patient had a scan pattern diagnostic of osteonecrosis three months following the onset of hip pain; radiographs and tomograms were normal at that time. Nonweight bearing was begun and three months later radiographs demonstrated osteonecrosis. In five patients scanning was not performed because symptoms were mild and persisted only a few days. No cases of bone or joint infection were encountered, but scanning was of value in ruling this out when suspected because of persistent arthralgia and synovitis. (auth)

17107 USE OF SCINTILLATION SCANNING FOR THE EARLY DETECTION OF BONE INVOLVEMENT BY SQUAMOUS CELL CARCINOMA OF THE ORAL MUCOSA: PRELIMINARY REPORT. Mashberg, Arthur; Strauss, Herbert; Small, Maurice J.; Miller, Wade N. (Veterans Administration Hospital, East Orange, N. J.). J. Amer. Dent. Ass.; 79: 1151-9(Nov 1969).

Five patients with a proved tissue diagnosis of squamous cell carcinoma of the oral cavity were subjected to a scanning procedure. A 100-$\mu$Ci dose of $^{85}$Sr as the nitrate was administered intravenously. Uptake by bone occurs immediately; however, it was found that scan results were better if a period of 5 to 7 days ensued between injection of isotope and scan. At this time, uptake was maximum and body background was low. A photoscan and a colorscan were obtained in each instance. Their interpretation was based on the appearance of abnormal concentrations, or hot spots, of $^{85}$Sr in appropriate areas, as contrasted with the homogeneous background of the surrounding bone. This preliminary study indicated the validity of scintillation scanning with $^{85}$Sr for early detection of bone involvement by squamous cell carci-

noma of the oral mucosa. In one case, bone involvement by squamous cell carcinoma appeared to be detectable before its appearance on the radiograph. In another case, it appeared that reactive osteogenesis associated with invasive carcinoma also may be detected. (BBB)

17108 COMPARATIVE THERMOLUMINESCENT DOSIMETRY OF INTRAORAL PERIAPICAL RADIOGRAPHY. Weissman, Donald D.; Sobkowski, Frank J. (Univ. of California, Los Angeles). Oral Surg., Oral Med., Oral Pathol.; 29: 376-86(Mar 1970).

X-radiation exposure levels resulting from each of four methods of periapical survey by intraoral radiography were monitored for sixty patients. $CaF_2$: Dy thermoluminescent dosimeters were exposed simultaneously at eight anatomic sites. Irradiation of the cornea of the eye was reduced 97.2% by shielding the cone and rectangularly collimating the primary beam. Unshielded cone radiographic methods produced undesirable irradiation of tissues not related to the diagnostic image. Unshielded methods of periapical radiographic survey should no longer be considered professionally acceptable procedures by modern standards. (auth)

17109 $^{99m}$Tc SULFIDE COLLOID SCANNING FOR BONE LESIONS. Du Sault, L. A.; Shaw, R. A.; Eyler, W. R. (Henry Ford Hospital, Detroit). Radiology; 94: 161-6(Jan 1970).

On a study of 25 patients, bone scanning with $^{99m}$Tc-sulfide colloid correlated well with bone scanning using $^{85}$Sr. In areas not obscured by liver or spleen, bone lesions were more readily apparent on $^{99m}$Tc scans than on $^{85}$Sr scans. Six cases are illustrated. (auth)

## Radiotherapy

*Refer also to abstracts 16797, 16994, 17052, 17053, 17153, 17158, and 17159.*

17110 MIXED TUMORS AND CARCINOSARCOMAS OF THE UTERUS EVALUATED FIVE YEARS AFTER TREATMENT. Schaepman-van Geuns, Eugenie J. (Academisch Ziekenhuis, Leiden). Cancer; 25: 72-7(Jan 1970).

A clinicopathologic study of 66 patients with 33 heterologous tumors and 33 carcinosarcomas followed for 5 yr after treatment is presented. The significantly better prognosis of the carcinosarcoma patients supports the opinion that subclassification of these types of neoplasms has practical value. The survival rate for both groups of tumors is influenced by the degree of myometrical invasion and the patient's age; these two factors bear an inverse relationship to survival time. A second malignant tumor was diagnosed in 7.5% of the patients. Prior irradiation was not an important factor. In this material, the 5-yr overall survival rate was 30% for mixed mesodermal (heterologous) tumors and 43.7% for the carcinosarcomas. (auth)

17111 THE VALUE OF ADJUVANT IRRADIATION IN THE TREATMENT OF ENDOMETRIAL CARCINOMA STATE I, GROUP I. Vongtama, Vitune; Kurohara, Samuel S.; Badib, Ahmed O.; Webster, John H. (Roswell Park Memorial Inst., Buffalo). Cancer; 25: 45-9(Jan 1970).

Four hundred ninety-seven cases of Stage I, Group I endometrial adenocarcinoma were treated by surgery alone (50 cases) or combined surgery and irradiation (447 cases). Radiation modalities used were uterine radium (327 cases), vaginal radium (30 cases), external pelvic irradiation plus radium (40 cases), and external pelvic irradiation alone (50 cases). The results of these different approaches were evaluated from the point of view of 5-yr cure rates, relative morbidity, and incidence of recurrence. Clinical evidence of increased cure rate was seen in those receiving adjuvant irradiation, although the difference was not statistically significant. The most favorable results followed adjuvant uterine radium and adjuvant external pelvic irradiation plus radium. The difference in uterine depth did not influence the results. The degree of differentiation of tumor and myometrial invasion was of prognostic significance. Adjuvant irradiation improved the results in less differentiated tumor. The presence of residual tumor in the removed uteri after irradiation had little influence on the prognosis. The combined effects of surgery and irradiation were well tolerated with a low morbidity rate. A decrease in the incidence of recurrence followed the use of all forms of irradiation. (auth)

17112 TREATMENT OF ADVANCED CANCER OF THE HEAD AND NECK. Ansfield, Fred J.; Ramirez, Guillermo; Davis, Hugh L. Jr; Korbitz, Bernard C.; Vermund, Halvor; Gollin, Frank F. (Univ. of Wisconsin, Madison). Cancer; 25: 78-82(Jan 1970).

The combination of radiation plus 5-fluorouracil (5-FU) produced a significantly increased survival in patients with advanced tonsil and intra-oral cancer compared to patients who received radiotherapy alone. There was no significant difference in survival between these two treatment modalities in advanced cancer of the nasopharynx, hypopharynx, extrinsic larynx, or primary unknown. Similarly, there was no significant difference in survival resulting from these two methods of treatment in patients with $T_1$ and $T_2$ as well as $T_4$ head and neck cancers, but a highly significant difference in those with $T_3$ lesions. (auth)

17113 THE USE OF THE SHUTTER ANGLE PROGRAMMER IN COBALT THERAPY. 1. CHANGES IN ISODOSE CURVES AND THE EXCLUSION OF OPPOSED SYMMETRICAL SEGMENTS. Dall'Acqua, R. (Univ. of Turin, Order of St. Maurice Hospital, Turin). Minerva Radiol.; 14: 436-42(Oct 1969). (In Italian).

A round and elliptical model were used to study changes in isodose curves resulting from the employment of the shutter angle programmer in cyclotelecobalt therapy. Curves obtained following the gradual closure of the arcs of opposed 30° and multiple 30° circles are presented. As far as the opposed fixed field technique is concerned, it was fould that field angles of about 60° have the advantage of equalizing the deep layer dose and of considerably decreasing that received by the surface layers. (auth)

17114 THE IMMEDIATE REACTION AND COMPLICATIONS IN ONCOGYNECOLOGICAL PATIENTS IN INHIBITORY HIGH-ENERGY RADIATION. Gabelov, A. A.; Strutsovskaya, S. V.; Stukova, L. M. (Central Research Inst. of Roentgenology and Radiology, Leningrad). Vop. Onkol.; 15: No. 12, 57-60(1969). (In Russian).

A clinical evaluation of reaction and complications observed during the process of radiation treatment of gynecological patients using inhibitory radiation of the linear accelerator 4.3 MeV is given. One hundred and fifty four patients were observed, 101 of them with cancer of the uterine cervix and 53—after radical surgery, performed for cancer of the endometrium, ovaries and other tumor diseases of the genitalia. The analysis of materials characterizing the incidence of local and general reactions in using inhibitory radiation of the linear accelerator does not permit to speak greater damage to organs and systems, than it is observed in using orthovoltage therapy. (auth)

17115 AN $^{192}$Ir APPLICATOR FOR ENDOLARYNGEAL RADIATION THERAPY. SEALED RADIOACTIVE SOURCES X. Nagli, G.; Brandt, R. H.; Vormum, G. (Deutsche Akademie der Wissenschaften, Berlin. Medizinische Akademie, Magdeburg, Ger.). Isotopenpraxis; 5: 349-51(Sep-Oct 1969). (In German).

An $^{192}$Ir applicator for endolaryngeal radiation therapy is described. It serves for endoscopic, epitumoural application of preselected radiation doses in tissue volumes of about 2 ml. As first clinical uses proved, the problems of radiation protection and of endoscopy will be solvable. (auth)

17116 RADIOLOGICAL APPEARANCES OF LYMPHOGRAMS PERFORMED AFTER RADIOTHERAPY. Markovits, P.; Blache, R.; Gasquet, C.; Charbit, A. (Institut Gustave Roussy, Villejuif, France). Ann. Radiol.; 12: R835-47(1969). (In French).

The radiological appearance of the lymphatic vessels and nodes underwent changes following radiotherapy in 30% of cases studied. The change consisted essentially of a network of fine hair-like vessels and the presence of aberrant channels without signs of impaired lymphatic drainage. The nodes appeared smaller and hypoplastic and their edges were often irregular. Histological examination suggested that the lymphographic appearances were caused by obliteration or destruction of the peripheral sinuses so that only the intermediate sinus is opacified. It is not at present possible to assess prognosis from these observations. The radiological changes corresponded to the areas irradiated. (auth)

17117 PITUITARY IRRADIATION THERAPY IN INFERTILITY. White, Margaret Moore. Int. J. Fert.; 14: 309-12(Oct-Dec 1969).

Effects of irradiation of the pituitary in 79 infertile women are reported. Treatment of the pituitary consisted of a total dose of 150 to 200 R distributed over a period of 4 to 6 weeks so that the pituitary was stimulated at the different phases of the menstrual cycle, should menstruation return during treatment. Treatment was with 230-KV x rays, using bilateral parallel opposed fields. Fifty-two of the women received pituitary hormones, and often estrogens and progestrogens prior to pituitary irradiation. A few were also given thyroid therapy. Women with masculinizing features were assessed for ketosteroid secretion and in 8 such cases prednisone was given prior to irradiation. Two of these women conceived and bore children subsequent to irradiation, and a third miscarried. Eight women conceived in the amenorrhea group, 15 in the irregularly anovulatory group, 12 in the regularly ovulating group, 3 in the poor secretory phase group, and 1 with low hormones, a total of 39, or 49%. Four women aborted,

but 3 conceived again and gave birth to a child. There was no abnormality detected in any of the children. Ovarian irradiation was carried out in 12 cases and although the pregnancy success rate was higher than with pituitary irradiation, it was discontinued because of possible adverse genetic effects. Two healthy grandchildren were born to women thus irradiated. (BBB)

17118 TREATMENT OF CARCINOMA OF THE BLADDER WITH COMBINED RADIOTHERAPY, CHEMOTHERAPY, AND SURGERY. Kaufman, Joseph J. (Univ. of California, Los Angeles). Arch. Surg.; 99: 477-83(Oct 1969).

On the basis of laboratory studies, clinical evaluation of the possible synergism between irradiation and cytostatic drugs was made in 76 patients with bladder cancer. The results of transplanting human bladder cancers to the cheek pouch of the cortisone-acetate-treated Syrian hamster and their treatment are reviewed. Results indicated the moderate effectiveness of fluorouracil and irradiation used individually and the enhanced effect of these agents when used in combination. Mitomycin-C in amounts beyond the safe human weekly dose produced the greatest inhibition of tumor growth. During treatment with 5-fluorouracil the patients with bladder cancer received $^{60}$Co teletherapy until a total tumor dose of 3500 R was reached. Toxicity was low and there were no deaths and no serious myelotoxic reactions. Diarrhea occurred in 5% of patients, and nausea and stomatitis occurred in 16% and 3% respectively. Thirty-seven patients also underwent cystectomy. The results showed that of 25 patients with A- and $B_1$-stage tumors, 15 were rendered tumor free after radiotherapy coupled with chemotherapy using fluorouracil. In the series of 17 patients with $B_2$- and C-stage tumors, 7 had tumor-free bladders following treatment. Five patients with $D_1$- and $D_2$-tumors lived 23 to 86 months in comfort. While not statistically significant because of small numbers, the figures indicate that there are improved results with combined therapy. (BBB)

17119 POSTOPERATIVE IRRADIATION FOR OVARIAN CARCINOMA WITH THE $^{60}$Co MOVING STRIP TECHNIQUE. Delclos, Luis; Fletcher, Gilbert H. (Univ. of Texas, Houston). Clin. Obstet. Gynecol.; 12: 993-1002(Dec 1969).

Results are reported on a group of patients with ovarian carcinoma treated postoperatively using the $^{60}$Co moving strip technique for irradiation (2000 rads) of the whole abdomen with liver and kidneys shielded and additional treatment (2000 rads) to the pelvic area. Data show that this is a more effective treatment modality than irradiating the whole abdomen or pelvis alone. (C.H.)

17120 TREATMENT OF ADVANCED CANCER OF THE HEAD AND NECK WITH INTENSIVE PREOPERATIVE IRRADIATION AND RADICAL SURGERY. Sanfilippo, Louis J.; Lane, Stanley L.; Sherman, Pincus; Pauporte, Jacques; Steichen, Felicien M. (Albert Einstein Coll. of Medicine, Bronx, N. Y.). Amer. J. Surg.; 118: 701-7(Nov 1969).

Side effects and clinical results of preoperative irradiation are reported in 45 patients subjected to $^{60}$Co irradiation. Irradiation of primary lesion and included neck disease was given at the tumor dose rate of 1250 R/week in most cases. The total tumor dose was 5000 or 6000 R. Irradiation to the neck separate from the primary lesion was given at the rate of 1250 R/week (surface dose or given dose) to totals of 5000 to 7000 R. Five patients had skin transferred in heavily irradiated tissue, either at the time of initial surgery or secondary reconstructive procedure. Two of these patients had split skin grafts; two had cervicothoracic pedicle flaps raised in stages; and one had a forehead flap raised and placed at the time of the combined procedure. All skin grafts took primarily. In most patients (64.4%) healing took place without complications. Complications included: eight of a transient nature, one case of wound dehiscence, one case of exposed bone, one marked edema of floor of mouth, one marked edema of lip with draining sinus, one skin infection, one suture sinus, one wound dehiscence, and one small necrosis of skin flaps; and 8 of a persistent nature: two fistulas, four bone necrosis, one necrosis of floor of mouth and jaw, with fistula, and one small necrosis of skin flaps. Preoperative irradiation was more successful in sterilizing advanced primary tumors than advanced cervical metastases. Combined treatment of advanced cancer of the larynx, pyriform sinus, antrum, and oral cavity achieved a high degree of control of the primary lesion. Combined treatment of predominantly advanced clinical neck metastases was moderately successful. (BBB)

17121 AMYLOID IN LATE POSTIRRADIATION NECROSIS OF BRAIN. Mandybur, T. I.; Gore, Ira (Univ. of Cincinnati). Neurology; 19: 983-92(Oct 1969).

The presence of amyloid in irradiated human brain is described with reference to two cases. In one case, a 54-year-old woman was treated for a basal-cell carcinoma of the right side of the scalp. The lesion recurred after five years and was treated with radiation (3880 rad (air dose) administered in 2 doses to a 2.5-cm$^2$ field using x rays of 100 KV). Because of recurrence, a second series of 3 treatments, totaling 5100 rad was given five yrs later. A third series of five treatments totaling 7800 rad (air dose) was given 3 yr later. The severity of the postirradiation reaction necessitated debridement and skin grafting. In case 2, a 62-year-old woman received x-ray therapy for a basal-cell carcinoma of the scalp. She developed a severe local postirradiation reaction. The histologic features of postirradiation lesions in the brain are described. A coagulative type of necrosis suggested an ischemic origin. In both cases, the amorphous deposit staining with Congo red was limited to the areas of necrosis and was often accompanied by severe fibrillary gliosis. The amorphous substance infiltrated necrotic vessels, completely or partially, and accumulated in perivascular regions, simulating perivascular amyloid deposits observed elsewhere. The observations emphasize the importance of necrosis in the development of postirradiation amyloid deposition. The long interval between the administration of x rays and the manifestations of damage indicated that vascular lesions develop slowly, presumably as a consequence of impaired cellular turnover and reconstitution. (BBB)

# Radiation Effects on Animals

17122 COMPUTER PROGRAMMES FOR FITTING PUCK AND PROBIT SURVIVAL CURVES. Gilbert, C. W. (Christie Hospital and Holt Radium Inst., Manchester, Eng.). Int. J. Radiat. Biol.; 16: 323-32(1969).

Computer programmes are described for analyzing Puck and probit survival curves. The input format allows considerable flexibility in making comparisons between different groups of data, and the data can be weighted in accordance with the methods used to estimate the surviving fraction. The basic mathematical principles are given in an appendix. (auth) (UK)

## *Invertebrates*

*Refer also to abstract 17036.*

17123 EXPERIMENTAL SEXUAL STERILIZATION OF COCKCHAFER MALES BY IONIZING RADIATIONS. Polozhentsev, P. A.; Tavolzhanskii, D. I. (Voronezh Forestry Inst., USSR). Radiobiologiya; 9: 897-900(Nov-Dec 1969). (In Russian).

A number of sessions of irradiation of seedlings with $\gamma$- and x rays at doses from 1000 to 8745 R were conducted. Complete sterilization of cockchafer males begins with $\gamma$-irradiation at a dose of 3300 R, and at 4020 R for x-irradiation. It was found that irradiation of the beetles at doses up to 8745 R does not produce any appreciable decreases in their activity in feeding, in seeking females and copulating with them, and in their lifetime. (tr-auth)

17124 EFFECTS OF X-RAYS ON MORPHOGENESIS IN THE HOUSEFLY. Sivasubramanian, P.; Bhaskaran, G.; Nair, K. K. (Bhabha Atomic Research Centre, Bombay. Simon Fraser Univ., Burnaby, B. C.). J. Insect Physiol.; 16: 89-97(Jan 1970).

Studies on the radiosensitivity of the imaginal disks in developing housefly pupae show that morphogenetic movements associated with the eversion of the head and appendages are not affected by doses of x rays up to 10,000 R, whereas differentiation is drastically affected. With increase in age of the pupa at the time of irradiation, there is a progressive reduction in the incidence of morphological abnormalities. It is also evident that there is an anteroposterior gradient with respect to radiosensitivity and that it corresponds to the temporal pattern of differentiation. The head is the most resistant to radiation, the thorax less so, and the abdomen is the most sensitive. The epidermal cells of the head and thorax are less sensitive than those of the abdomen. The various imaginal disks show differential sensitivity to x radiation. Moreover, the different fields in a single disk are also differentially sensitive to x radiation. The prothoracic leg disks are the most resistant followed by the meso- and metathoracic leg disks. In addition, the distal regions of the appendages are more resistant than the proximal ones. In irradiated groups, the appendages of the head are reduced in size but are well differentiated, whereas the thoracic appendages, though of normal length, are poorly differentiated. The critical phase of radiosensitivity of the developing imaginal disks ends after the evagination of the head, and probably reflects the completion of the gene activation process in the cells. (auth)

17125 LETHAL EFFECTS OF GAMMA RADIATION ON THE SCHISTOSOME LARVA CARRIER SNAIL (AUSTRALORBIS GLABRATUS). Farvar, Mirza A.; Cember, Herman (Northwestern Univ. Tech. Inst., Evanston, Ill.). Amer. J. Public Health; 59: 2077-80(Nov 1969).

Five groups of 3 to 5 month old snails were placed in beakers containing pond water and γ-irradiated at doses of 75 to 250 kilorads. Following irradiation, the snails were observed microscopically at intervals up to 11 days. Within half an hour all snails showed marked radiation injury. Radiation doses of 150 to 250 kilorads resulted in destruction of all snails within 19 hours. (H.L.W.)

17126 CELLS INVOLVED IN THE IMMUNE RESPONSE. XVI. THE RESPONSE OF IMMUNE RABBIT CELLS TO PHYTOHEMAGGLUTININ, ANTIGEN, AND GOAT ANTI-RABBIT IMMUNOGLOBULIN ANTISERUM. Daguillard, Fritz; Richter, Maxwell (Royal Victoria Hospital, Montreal). J. Exp. Med.; 131: 119-31 (1 Jan 1970).

There exists in the γ-irradiated rabbit a population of lymphocytes carrying immunoglobulin-like receptors on their surface. These receptors interact with antigen and with anti-immunoglobulin antibodies and appear to mediate the recognition process leading to the humoral immune response. There exists in the rabbit a second population of lymphocytes capable of reacting with phytohemagglutinin. This population of lymphocytes is different from the one capable of reacting with soluble protein antigens or anti-immunoglobulin antiserum and is probably involved in the mediation of cellular immunity. (auth)

17127 RESCUE OF SUPRALETHALLY X-IRRADIATED AMOEBAE WITH NONIRRADIATED CYTOPLASM. Daniels, Edward W.; Breyer, Evelyn P. (Argonne National Lab., Ill.). Radiat. Res.; 41: 326-41(Feb 1970).

The radiosensitive amoeba, Pelomyxa illinoisensis, dies 4 to 6 days after supralethal exposure to x rays (30 kR), and cell division rarely occurs before death. Irradiated amoebae survive and reproduce when they are microsurgically fused with portions of similar but nonirradiated amoebae. Thirty-eight supralethally x-irradiated amoebae were thus injected with completely enucleated cytoplasm from the centripetal halves of nonirradiated donor amoebae centrifuged at 700 × g for 10 min. This treatment resulted in recovery of 58%, and a significant increase in the survival time of an additional 26%, but it was nonbeneficial to the remaining 16%. Cytoplasm from the centripetal portions of nonirradiated amoebae centrifuged at 7,000 × g for 10 min was not restorative; unlike the restorative 700 × g centripetal portions, these lacked polysome-laden 0.1 to 0.5 μ vesicles, and there appeared to be fewer monosomes and disomes. Nearly all clusters of three or more ribosomes were removed from both 700 × g and 7,000 × g centripetal portions. The centrifugal halves of both 700 × g and 7,000 × g donor amoebae were radiorestorative; they contained many clusters of ribosomes, submicron vesicles with polysomes on their surfaces, all of the nuclei, crystals, and most mitochondria. Available information suggests: the restorative agents are in particulate form and are removed from the centripetal halves in 10 min at 7,000 × g but not 700 × g, they contain cytoplasmic RNA because they are inactivated by 253.7-nm uv radiation, and donor nuclei are not required for radiorestoration. Lethal radiation damage from both ionizing and uv radiation probably occurs in the DNA of these amoebae, as well as in both nuclear and cytoplasmic RNA. The repair of DNA may be blocked by the impairment of polyribosome function. (auth)

17128 PRELIMINARY OBSERVATIONS ON THE BIOLOGICAL EFFECT OF UV RAYS ON THE LIFE CYCLE OF STRONGYLOIDES PAPILLOSUS. Stankiewicz, M.; Sinski, E.; Bezubik, B. Bull. Acad. Pol. Sci., Ser. Sci. Biol.; 17: 459-61(1969).

The effects of uv radiation on the infective larvae of Strongyloides papillosus were studied using various time intervals of irradiation (30 sec to 15 min). These preliminary studies indicated marked effects of uv on the life cycle of Strongyloides papillosus. An appropriate irradiation of larvae (5 or 15 min) made the parasite unable to start the initial migration. Rabbits infested with larvae and exposed to 2-min irradiation showed only a few larvae in the lungs and no adult parasites in the intestine. The most effective time of irradiation was found to be 90 sec. At this time the larvae performed normal migrations in the body of the host, transformed into adult females in the intestine, but did not produce eggs. On the other hand, shorter times of irradiation (60 and 30 sec) did not affect the normal development of larvae, and the numbers of larvae in the tissues, numbers of adult parasites in the intestines, and the egg-per-gram production values were similar to those occurring in rabbits exposed to normal (nonirradiated) larvae. (BBB)

17129 IRRADIATION OF SPERM TAILS BY LASER MICROBEAM. Goldstein, Stuart F. (Univ. of California, Berkeley). J. Exp. Biol.; 51: 431-41(Nov 1969).

Sea-urchin and starfish sperm tails were irradiated at preselected points along the flagellum and at preselected phases of the beat cycle by means of a pulsed ruby laser microbeam. Multiple-exposure dark-field photomicrographs were taken immediately before and after irradiation. The flagellum usually appeared to be broken at the irradiated point. The portion of a flagellum between the head and the irradiated point continued for at least a few beats if its length was at least 25% of the length of the tail, and stopped immediately if it was shorter. Bends already established beyond the irradiated point continued to propagate to the tip of the flagellum. Their propagation velocity generally decreased, and there were usually changes in other bend parameters. No new bends ever developed beyond the irradiated point. Irradiation within a bent region often completely eliminated that region. (auth) (BBB)

17130 ORIGIN OF REGENERATION CELLS IN ARICIA FOETIDA CLAP. (ANNELID POLYCHAETE). Boilly, Benoni (Faculte des Sciences, Lille). Arch. Anat. Microscop. Morphol. Exp.; 57: 297-308(Jul-Sep 1968). (In French).

X irradiation was used to study the origin of caudal regeneration cells in Aricia foetida (var. atlantica) by a histological study of the first stages of regenerative histogenesis. Irradiation was carried out with 90-KV x rays delivered at a dose rate of 340 R/min. Either whole-body irradiation was given at 5000 to 30,000 R (24 hr after section) or local irradiation of 10,000 R. Histological study showed that every regenerated layer proceeds from old tissue situated near the section plane (epidermis, intestinal epithelium, coelomic epithelium) and perhaps dedifferentiated muscle fibers and originated from the corresponding embryonic layer. The experiments with total and local irradiation demonstrated that mesodermal blastocytes regenerate only mesoderm and that they come only from the segment contiguous to the wound. Therefore, these results invalidate earlier conclusions on the existence of totipotents and migratory neoblasts in this annelid. (BBB)

## Vertebrates

*Refer also to abstracts 16953, 16960, 16964, 16973, 16974, 16976–16980, 16982, 16983, 16986–16988, 16990, 16994, 17002, 17003, 17005–17009, 17027, 17030, 17033, 17035, 17056, and 17059–17069.*

17131 (AD-695769) ACUTE MORTALITY RESPONSE OF THE MINIATURE PIG TO PULSED MIXED GAMMA–NEUTRON RADIATIONS. Wise, D.; Turbyfill, C. L. (Armed Forces Radiobiology Research Inst., Bethesda, Md.). Jul 1969. 22p. (AFRRI-SR-69-10). CFSTI.

Miniature pigs were exposed unilaterally to mixed gamma-neutron radiations from the AFRRITRIGA reactor delivered in a single pulse. Seventy-one miniature pigs received midline tissue doses ranging from 183 to 335 rads. The $LD_{50/45}$ was 218 rads. Survival times ranged from 10 to 22 days, and the mean survival time for all decedents was 15.1 days. Clinical symptoms and pathological changes are reported. (auth) (TAB)

17132 (AD-695770) EFFECT OF MIXED GAMMA–NEUTRON RADIATIONS ON PLASMA AND URINE AMINO ACID LEVELS IN THE RAT. Roderick, U.-R.; Strike, T. A. (Armed Forces Radiobiology Research Inst., Bethesda, Md.). Sep 1969. 25p. (AFRRI-SR-69-11). CFSTI.

Approximately 27 acid or neutral and 13 basic amino acids and metabolites were quantified in plasma and urine of Sprague-Dawley rats 24, 48, and 72 hours after 740- to 10,000-rad doses of mixed gamma-neutron radiations. None of the postirradiation alterations in the plasma concentrations and urinary excretion rates of these compounds has any value as a biological dosimeter or indicator of radiation damage in the dose range investigated. (auth) (TAB)

17133 (UCSF-10-P-2-96) RECONSTITUTION OF BONE MARROW IN A DEPLETED MEDULLARY CAVITY. Patt, Harvey M.; Maloney, Mary A. (California Univ., San Francisco. Lab. of Radiobiology). [1969]. 28p. Dep. CFSTI.

The femur diaphysis of rats can be evacuated in vivo simply by aspiration and simultaneous perfusion with dextran. This has provided a useful experimental model for study of the phenomenon of bone marrow reconstitution. Marrow restoration in the evacuated femur was examined by cytokinetic and histologic techniques in conjunction with radiation studies. The results of these investigations indicate that: the restoration of marrow in a mechanically depleted site is a local phenomenon in regard to both the stimulus for regeneration and the origin of the responsible cells; the regenerative process stems from mesenchymal cells in the connective tissue of the Haversian canals and development of the marrow structure depends upon subsequent interactions of these cells and their derivatives in a manner not unlike that after bone fracture; and trabeculization of the medullary cavity seems to be an important feature of the regenerative process, perhaps because it creates an environment or provides a source of progenitor cells

or both. Mesenchymal cells can be quite x radiosensitive as shown by an $ED_{50}$ of about 400 R for delay of marrow restoration in an empty femur shaft. X irradiation with 1000 R had a greater effect on the just evacuated femur than on the normal femur. However, when irradiation took place nine days after femur evacuation, even though there were few recognizable hemic cells, the response to 1000 R closely resembled that of intact marrow. Development of a fibrotic marrow after removal of normal marrow is a rare occurrence. Yet, the fact that it can occur suggests that an aberration of mesenchymal elements in bone may play an important role in the genesis of idiopathic myelofibrosis. (auth)

**17134** ELEKTROMAGNETICKE POLE A ZIVOTNI PROSTREDI. (Electromagnetic Field and Living Organisms). Marha, Karel; Musil, Jan; Tuha, Hana. Praha; Statni Zdravotnicke Nakladatelstvi (1968). 131p.

Industrial, biological, and medical aspects of intense microwave effects on living organisms were studied. Effects of high-frequency electric fields on living cells, changes in blood composition during short-wave exposure, reactions of bone, bone marrow, and adjacent tissue to microwaves, electrical potential in nerves and muscles, testicular degeneration as a result of microwave irradiation, and other biological hazards are discussed as well as protective measures for personnel exposed to microwave radiation. (R.V.J.)

**17135** TRANSFER OF WATER AND DRUGS BY THE ISOLATED INTESTINE OF γ-IRRADIATED RAT. Mattila, M. J.; Takki, S.; Holsti, Lars R. (Univ. Central Hospital, Helsinki). Arzneim.-Forsch., 18: 889-90(July 1968).

The effect of irradiation on drug absorption from the gastrointestinal tract, which mostly takes place by simple diffusion was studied. Rat intestinal segments removed 2, 4, or 6 days after 700 R whole-body $^{60}Co$ γ irradiation were used. The technique allowed direct measurement of the volume and drug content of fluid transferred by the intestinal wall. Irradiation irregularly increased the volume of Krebs saline passed through the intestinal wall. With 2-ethylisonicotinthioamide (ethionamide) in perfusion fluid, both the passed fluid volume and its drug concentration increased after irradiation, the maximum effect being 2 to 4 days after irradiation. The absorption of ethionamide from toxic concentrations that depressed the water transfer in control preparations was also enhanced. The absorption of acetylsalicylic acid was enhanced without any increase in the water transfer. The formation of salicylic acid in the intestinal wall was slightly but not significantly decreased. Irradiation did not enhance the transfer of N,2,3,3-tetramethylnorbornamine (mecamylamine), but in some experiments, it was impaired. The results suggest that the intestinal barrier to highly ionized organic bases may be more resistant to irradiation than the barrier to some other drugs. (TSS) (BBB)

**17136** INTERRELATION BETWEEN THE PERIODS OF REGENERATION OF LYMPHOID TISSUE AND THE LIFETIMES OF SKIN TRANSPLANTS IN IRRADIATED ANIMALS. Aripov, U. A.; Arustamov, D. L.; Nazarov, E. N.; Nikolaev, A. I.; Rozgon, M. I. (Tashkent State Medical Inst.). Radiobiologiya; 9: 829-31(Nov-Dec 1969). (In Russian).

The relation between the periods of onset of postradiation regeneration of lymphoid tissue (considering the restoration of the antibody-forming cells as well), the duration of the inductive phase of antibody formation, and the periods of rejection of a skin homotransplants in white mice and rats after irradiation with 400, 600, and 700 R was investigated. It was shown that the lifetime of a skin transplant is definitely related to the periods of onset of postradiation regeneration of the lymphoid tissue and the duration of the inductive phase of antibody formation. (tr-auth)

**17137** CALCULATION OF THE EFFECTIVE DOSE IN THE CASE OF BRIEF IRRADIATION OF ANIMALS. Gushchin, V. A.; Baibara, N. B. (Inst. of Biophysics, Moscow). Radiobiologiya; 9: 937-41(Nov-Dec 1969). (In Russian).

In calculating the residual radiation damage $D_e$ according to the method of repeated brief irradiations, it must be considered that part of the animals may die of the original brief irradiation as a result of acute radiation sickness. After measuring $D_e$ for a number of factors, one can determine the maximum probable values of the fraction of irreversible damage according to the method of least squares. (tr-auth)

**17138** RADIATION DAMAGE TO THE REGENERATING RAT CEREBELLAR CORTEX. Korogodina, Yu. V. (Inst. of Medical Radiology, Obninsk, USSR). Radiobiologiya; 9: 859-62(Nov-Dec 1969). (In Russian).

A histological study was made of the cerebellar cortex of rats of different ages, subjected to whole-body irradiation, once or repeatedly, with γ rays from $^{60}Co$ at doses of 400 or 600 R. The cells of the outer granular layer surviving after the first irradiation possess relative stability to the lethal effects of repeated irradiation, as long as they do not begin to proliferate. The dividing cells of the matrix and their offspring, that provide for postradiation regeneration of the cerebellar cortex, are just as highly sensitive to irradiation as the cells of the outer granular layer of the cortex of nonirradiated animals of the corresponding age. (tr-auth)

**17139** EFFECTS OF X IRRADIATION ON THE RETINA OF GRASS FROG TADPOLES. Sokolova, Z. A.; Gusovskaya, A. A.; Popov, V. V. (Moscow State Univ.). Radiobiologiya; 9: 863-7 (Nov-Dec 1969). (In Russian).

The effects of x irradiation at doses of 30, 300, and 1500 R on the retina of the grass frog tadpole were investigated. The radiosensitivity of the retina differs in different portions. It is highest at the boundary between the matrix and the rudiment of the ciliary body; it is somewhat lower in the region of the matrix and peripheral retina; and lowest in the differentiated retina. (tr-auth)

**17140** QUANTITATIVE METHODS OF EVALUATING THE RADIOSENSITIVITY AND RADIOSENSITIZATION OF TUMORS BY CHEMICAL COMPOUNDS. Pelevina, I. I.; Afanas'ev, G. G. (Inst. of Chemical Physics, Moscow). Radiobiologiya; 9: 868-74(Nov-Dec 1969). (In Russian).

Methods of determining the dose $D_{37}$ of ascites and solid tumor cells and the significance of this parameter for predicting the response of a tumor to irradiation are discussed. A method is proposed for the quantitative evaluation of the effectiveness of irradiation of tumors, considering their heterogeneous response. The method consists of a differential analysis of lethally damaged tumors (being resorbed) and tumors continuing to develop. (tr-auth)

**17141** RESTORATION OF POTENTIAL LETHAL DAMAGES IN SYNCHRONIZED CHINESE HAMSTER CELLS IN VITRO. Mantsygin, Yu. A.; Bagrova, A. M. (Moscow State Univ.). Radiobiologiya; 9: 875-81(Nov-Dec 1969). (In Russian).

The effect of restoration of lethal and sublethal damages was studied on synchronized and asynchronous Chinese hamster cells in vitro. Incubation of irradiated cells in nonnutrient medium (phosphate buffer) did not lead to an increase in the survival of the cells. When the cells are irradiated in the $G_1$-stage, a decrease in the yield of cleavages per cell was detected due to a decrease in the frequency of fragments and microfragments. Thus, no complete correlation was obtained between the yield of certain types of chromosome aberrations, expressed in the first postradiation mitosis, and the survival rate of the cells. (tr-auth)

**17142** INVESTIGATION OF WATER-SOLUBLE RADIOTOXINS FORMED IN THE LIVERS OF γ IRRADIATED RATS. Merkulov, A. S.; Kuzin, A. M. (Inst. of Biological Physics, Pushchino, USSR). Radiobiologiya; 9: 816-19(Nov-Dec 1969). (In Russian).

A method was developed for isolating a polarographically active water-soluble substance ($E_{\frac{1}{2}} = -0.35$ V). Its molecular weight and uv-absorption spectrum were determined, and it was demonstrated experimentally for the first time that low concentrations of this substance activate the processes of plant growth, while high concentrations inhibit them. (tr-auth)

**17143** A CONTRIBUTION TO THE HERD DIAGNOSIS OF ACUTE RADIATION SICKNESS IN HOGS. Mehlhorn, Guenther (Karl Marx Univ., Leipzig). Arch. fuer Exp. Veterinaermed.: 23: 419-31(Jun 1969). (In German).

The symptoms of radiation sickness in its acute form in hogs were described. Photographs of diseased heart, intestines, bladder, skin, marrow, and lymph nodes were shown. Early stages of the disease become evident by changes in leukocyte count in the peripheral blood. Usually, one suspects radiation sickness if there had been an exposure to radiation beforehand. The histological changes described can provide positive identification. Sampling of a herd to obtain representative findings was discussed. (JPRS)

**17144** INFLUENCE OF X RAYS ON HIGHER NERVOUS ACTIVITY IN ANIMALS. Marza, V. L. Oncol. Radiol.: 7: 435-41(1968). (In Rumanian).

Perturbation of the higher nervous activity in dogs was followed up after repeated overall x-ray exposures to doses of 20 R daily and to a total dose of 200 R. The early disturbances induced by radiation were characterized by a state of hyperexcitability, against which ever more frequent and stronger inhibition states were recorded, after a month and fifteen days inhibition prevailed. After a two-month-interval of discontinuity the same picture developed: hyperexcitability, reflexes oscillating around average values, reflex collapse followed by a strong state of supraliminal inhibition. Hypnotic states were noted in over 50%

of the cases. No difference was observed in reactivity with the type of nervous system. However, disturbances occurred earlier and were more significant in the weak and moderate types. (auth) (Rom. Sci. Abstr.)

**17145** CARCINOGENESIS BY RNA SARCOMA VIRUSES. XII. A QUANTITATIVE STUDY OF INFECTION OF RAT CELLS IN VITRO BY AVIAN SARCOMA VIRUSES. Altaner, C.; Temin, H. M. (Univ. of Wisconsin, Madison). Virology; 40: 118-34 (Jan 1970).

A quantitative in vitro assay was developed for avian sarcoma viruses capable of converting rat embryo fibroblasts. The physical properties of the agent capable of converting rat cells are the same as those of the virion of avian sarcoma virus. Avian sarcoma virus recovered after passage through converted rat cells is genetically altered having increased plating efficiency on rat cells and altered antigenicity. The plating efficiency on rat cells is not correlated with the type-specific antigen of the virus. Phenotypically mixed virus has plating efficiencies on duck and rat cells like virus with the same genome, not like virus with the same envelope. Treatment of rat cells with inactivated Sendai virus does not greatly increase the plating efficiency of avian sarcoma viruses on these cells. Therefore, passage of avian sarcoma virus through rat cells results in virus that is genetically altered in two separate phenotypic properties. A model to explain these results involving recombination between the avian sarcoma virus and the host genome is proposed. (auth)

**17146** PROGNOSING THE OUTCOME OF IRRADIATION IN MAMMALS. Graevskaya, B. M.; Nechaev, I. A.; Zolotareva, N. N. (Inst. of Biological Physics, Pushchino-Na-Oke, USSR). Dokl. Akad. Nauk SSSR; 189: 655-7(21 Nov 1969). (In Russian).

An attempt was made to relate individual differences in radiosensitivity with metabolic factors such as the sugar level in the peripheral blood, the response of the blood sugar level to the introduction of adrenaline, and the rate of proteolytic processes in the whole blood. The number of leukocytes in the peripheral blood of the animal is an additional indicator of radiosensitivity. All these factors can be determined without destroying the animal, and can be related to the radiosensitivity of the individual. These tests were run on Wistar rats who were given x ray doses from 500 to 675 R. A plot of the number of deaths against the irradiation dose gave a straight-line relationship. By using the sum of the indicators on an individual animal it was possible to predict whether or not any individual would die or survive in 30 out of 38 cases. The prediction accuracy was 79 ± 7%. In the other 20% of the cases the summation gave indefinite results. (TTT)

**17147** SIMULATED RADIATION FIELDS FROM $^{238}$Pu-FUELED ARTIFICIAL HEARTS: LONG TERM EFFECTS OF INTRACORPOREAL $^{90}$Sr, $^{241}$Am, AND Be SOURCES. Sandberg, Glenn W. Jr.; Lee, Rosemary C.; Pegg, Christopher A. S.; Huffman, Fred N.; Norman, John C. (Boston City Hospital). Contract PH43-66-982. Surg. Forum; 20: 194-6(1969).

From 55th Annual Clinical Congress, San Francisco, Calif. See CONF-691028-(Absts.).

Two dogs are living 14 months, and another 11 months, with continuous intracorporeal neutron and photon irradiation, equivalent to that from a projected implantable 24 watt $^{238}$Pu power source for an artificial heart or circulatory-assist device. Their survival with normal physiologic and metabolic indices and their ability to conceive and deliver apparently normal offspring without radiation damage suggest that implanted radioisotope power sources for artificial hearts may be practicable. (auth)

**17148** EFFECTS OF INTERNAL IRRADIATION OF THE MAMMARY GLAND WITH $^{144}$Ce–$^{144}$Pr. Swanson, E. W.; Miller, J. K.; Cragle, R. G. (Univ. of Tennessee, Knoxville. UT-AEC Agricultural Research Program, Oak Ridge, Tenn.). Contract AT(40-1)-GEN-242. J. Dairy Sci.; 53: 46-51(Jan 1970).

Left udder halves of two Jersey cows were given intramammary infusions at six-week intervals with $^{144}$Ce–$^{144}$Pr to give approximately 975, 650, and 1,300 rad per treatment. Two other cows were given left-half treatments of 650 and 1,300 rad 64 days apart. Milk yield of the treated halves remained comparable to that of the control halves until the last treatments, when it declined. Reduced hay consumption accompanied the decline in milk yields. Milk composition of treated and control halves did not differ significantly. One cow in a succeeding lactation showed a marked reduction of yield in the irradiated half. Nearly 15% of the radioactivity was retained in the body. High concentrations of $^{144}$Ce–$^{144}$Pr accumulated in the liver, spleen, skeleton, and treated half mammary lymph glands. Histological evidence of damage to the mammary secretory epithelium was noted. Chronic hematopoietic damage occurred that resulted in death of three of the cows about four months after the last treatment. The fourth cow died 2 yr later with extensive edema involving the left half of the udder. It was concluded that the mammary gland secretory epithelium is relatively resistant to irradiation damage, but is measurably affected at doses of 1,300 rad. Effects on the mammary glands could not be completely separated from possible systemic effects of absorbed $^{144}$Ce–$^{144}$Pr. (auth)

**17149** KILLING OF CULTURED MAMMALIAN CELLS BY RADIOACTIVE DECAY OF TRITIATED THYMIDINE AT –196°C. Burki, H. John; Okada, S. (Univ. of Rochester, New York). Contract AT(30-1)-1286. Radiat. Res.; 41: 409-24(Feb 1970). (UR-49-825).

Deoxyribonucleic acid of mammalian cells (L5178Y) in culture was labeled uniformly in one of the following three ways: incubation with tritium-labeled thymidine for one generation (unifilar labeling), incubation with tritium-labeled thymidine for four generations (bifilar labeling), and incubation with tritium-labeled thymidine for four generations plus one generation without tritium-labeled thymidine (reverse unifilar labeling). The cells were frozen and stored in liquid nitrogen. After various storage times, their survivals were estimated. The survival curves of cells with unifilar labeled DNA were approximately exponential. The survival curve of the cells with bifilar labeled DNA was similar to that of the unfilar labeled cells to around 20% survival. Below 20% survival, the slope of the survival curve was greater by a factor of 2 than that of the unifilar labeled cells. (auth)

**17150** A PRELIMINARY STUDY ON SOME TERATOGENIC EFFECTS OF X IRRADIATION COMBINED WITH FASTING ON INBRED MOUSE EMBRYOS. Shoji, Ryujiro; Kohno, Sei-ichi; Ohzu, Eiji (Hokkaido Univ., Sapporo). Jap. J. Zool.; 16: 47-52(Mar 1969).

The combined tetratogenic effects of fasting and x-irradiation were studied with special regard to the morphological character in mice of inbred strains. Two inbred strains of mice dd and Swiss-albino were subjected to fasting for 24 hr from the 8th day to 9th day of gestation. After fasting they were immediately exposed to whole-body x-irradiation of 200R. The females were sacrificed on the 18th day of pregnancy, and the fetuses were examined for gross external malformations under a dissecting microscope. Fetal death occurred in both the control and the experimental mice in both strains, but fetal mortality in Swiss-albino mice was higher than in dd mice. However, the difference in the number of dead fetuses between the control and the experimental mice in each strain was not statistically significant. Eight types of fetal malformations were observed: forefoot anomaly, omphalocele, open eyelid, exophthalmos, short tail, agnathia, forefoot polydactyly, and hindfoot polydactyly. Some representative malformations are illustrated. The first 5 types were found only in fetuses from mice treated with both x irradiation and fasting. The frequency of anomalies in the dd strain increased significantly when irradiation was combined with fasting, but it did not in Swiss-albino mice. It is concluded that effects of x irradiation plus fasting in mouse embryos may differ in different strains. (BBB)

## Man

*Refer also to abstracts 17017, 17034, 17110, 17114, 17116, and 17117.*

**17151** EFFECT OF SUNLIGHT ON HUMAN EPIDERMIS. A QUANTITATIVE ELECTRON MICROSCOPIC STUDY OF DENDRITIC CELLS. Zelickson, Alvin S.; Mottaz, Jess (Univ. of Minnesota, Minneapolis). Arch. Dermatol.; 101: 312-15(Mar 1970).

Qualitative as well as quantitative studies, including direct counting of cells and linear scanning of electron micrographs, to determine volume ratios for epidermal dendritic cells revealed an increase in melanocyte number and an essential absence of Langerhans' cells following two weeks of daily ultraviolet irradiation. These findings suggest some relation between the melanocyte and the Langerhans' cell. (auth)

**17152** INCIDENCE OF CUTANEOUS CANCER IN MINNESOTA. Lynch, Francis W.; Seidman, Herbert; Hammond, E. Cuyler (Univ. of Minnesota, Minneapolis). Cancer; 25: 83-91 (Jan 1970).

In a survey conducted in Minnesota, a special effort was made to record cases of cutaneous cancer encountered in 1963 by dermatologists, radiotherapists, and pathologists. The latter group probably includes almost all of the patients treated by surgeons in hospitals and the great majority of those treated by surgeons in their offices. In an earlier sample study, this was found to be true of general practitioners. A total of 2,358 Minnesotans was identified as having cutaneous cancer, presenting first during 1963. This

exceeded the most plausible estimates based on previously available data. The annual incidence rates recorded were 71.5 per 100,000 men and 47.2 per 100,000 women. These rates place cutaneous cancer clearly in front among types of cancer in Minnesota, although it is a northern state whose population has relatively low actinic exposure. (auth)

**17153** RADIATION-INDUCED SKIN CANCER OF THE HEAD AND NECK. Martin, Hayes; Strong, Elliot; Spiro, Ronald H. (Memorial Hospital for Cancer and Allied Diseases, New York). Cancer; 25: 61-71(Jan 1970).

This report concerns 368 patients who developed cancer in facial or neck skin who were previously irradiated for benign conditions. The biologic effects of ionizing radiation on skin are reviewed and the hazards of even moderate dosage for benign dermatoses are emphasized. More than two thirds of the tumors in this series were basal cell carcinomas; women predominated in a ratio of about 3 to 1. Although the median interval between x-ray exposure and diagnosis of skin cancer was 21 yrs, a causal relationship seemed obvious in three young patients after intervals of only 3 to 5 yrs. Latent intervals as long as 64 yrs suggest that the risk of carcinogenesis in irradiated skin persists for the life of the patient. The tumors usually occurred in the central areas of the face which showed the most extensive irradiation changes, but cancers not infrequently developed only in marginal areas where there were only moderate or minimal changes. Extensive ulceration and devitalization of the tumor bed and a tendency towards multiple lesions were especially characteristic of radiation-induced skin cancer. It appeared that the risk of regional and distant spread of radioinduced squamous cell carcinoma of the face and neck was substantially greater than that observed in its histologic counterpart of other etiology. Previous treatment had been given to 39% of the patients; all but a few were treated surgically in accordance with conventional techniques. Serious functional and cosmetic defects were not uncommon, particularly in patients who required more than one operation because of recurrence. There were 35 patients who died as a result of uncontrolled, radioinduced skin cancer. Conventional cure rates based on length of survival are considered meaningless when dealing with this etiologic type of cancer. (auth)

**17154** CUTANEOUS EFFECTS OF SUN EXPOSURE. Silvers, David N.; Cohen, Harvey J. (New York Univ., N. Y.). J. Amer. Med. Ass.; 211: 1377(23 Feb 1970).

The effects of prolonged exposure to sunlight on human skin are detailed in a case report of a man retired from a 63-yr career as a lifeguard. Severe hyperpigmentation and keratoses of the skin over 90% of the body are illustrated. The inevitability of skin deterioration from uv radiation following prolonged or repeated exposure to sunlight in people with poor mechanisms of melanogenesis is commented on. (E.R.B.)

**17155** RADIATION SENSITIVITY OF HUMAN BONE MARROW CELLS MEASURED BY A CELL CULTURE METHOD. Senn, J. S.; McCulloch, E. A. (Univ. of Toronto. Ontario Cancer Inst., Toronto. Sunnybrook Hospital, Toronto). Blood; 35: 56-60(Jan 1970).

A culture technique for measuring the proliferative capacity of a class of human hemopoietic cells is presented. This method was used to assess the $\gamma$-radiosensitivity of this class of human hemopoietic cells, and to compare them directly to mouse hemopoietic cells tested in the same system. It was concluded that the sensitivity of human bone marrow to irradiation as measured directly was of the same order as that predicted on the basis of experiments in mice. (auth)

**17156** EFFECT OF INCREASING EXPOSURES OF THE $^{10}B(n,\alpha)^{7}Li$ REACTION ON THE SKIN OF MAN. Archambeau, J. O. (Meadowbrook Hospital, East Meadow, N. Y. Brookhaven National Lab., Upton, N. Y.). Radiology; 94: 179-87(Jan 1970).

The evolution and time course of the moist reaction of the skin of man following increasing absorbed doses from the $^{10}B(n,\alpha)^{7}Li$ reaction are discussed. Erythema appeared a few hours after irradiation and reached maximum intensity between one and three days later before subsiding. The findings noted were similar to those previously seen in swine. (auth)

**17157** CARCINOMA OF THE THYROID AFTER EXTERNAL RADIATION TO THE NECK IN ADULTS. Block, Melvin A.; Miller, Martin J.; Horn, Robert C. Jr. (Henry Ford Hospital, Detroit). Amer. J. Surg.; 118: 764-9(Nov 1969).

Of the last 100 patients with carcinoma of the thyroid, seen in this institution between 1961 and 1968, at least 21 had received previous external radiation therapy to the neck region. Of these hundred patients, 18 were given external radiation therapy after one yr of age, with nine receiving radiation therapy after the age of 21 yrs. Of the total of 296 patients with thyroid carcinoma seen in this institution from 1924 to 1968, at least 42 (14%) had received external radiation therapy to the neck. Of these, 37 patients (13%) received the treatment after one yr of age. In 13 of the 42 patients (30%), one or more benign thyroid nodules were present in addition to the carcinoma. Three of the 42 patients died from thyroid carcinoma. In two patients malignant skin lesions developed in the head and neck region in addition to the thyroid carcinoma. The frequency of previous external radiation therapy to the neck region in this series suggests that irradiation was clinically important in the pathogenesis of thyroid carcinoma in patients of all ages. Surgery is especially urgent for thyroid nodules in patients who previously received radiation therapy. All patients having thyroid nodules should be queried for such a history. Patients receiving therapeutic radiation to the neck region should be examined periodically for the remainder of their life for evidence of neoplasms of the thyroid and adjacent structures. (BBB)

**17158** COMPUTER-BASED SCREENING SYSTEM FOR PATIENTS AT RISK OF HYPOTHYROIDISM. Barker, D. J. P.; Bishop, J. M. (Univ. of Birmingham, Eng.). Lancet; 2: 835-8(18 Oct 1969).

As a late complication of the radioiodine therapy for thyrotoxicosis, development of hypothyroidism may occur many years later. It is therefore necessary for all patients treated with $^{131}I$ to have some form of periodic assessment. The system described was designed to detect $^{131}I$-induced hypothyroidism by maintaining continuous surveillance of all thyrotoxic patients treated with radioiodine. Once hypothyroidism is diagnosed, replacement therapy is initiated by the consultant responsible for the $^{131}I$ treatment. The system makes use of nonmedical personnel wherever possible; a computer processes and stores the data; and a new method of analyzing symptom patterns is employed. It depends on periodic measurement of the serum protein-bound iodine and analysis of patterns of replies to a postal questionnaire. Out of 213 patients 38 were found to be hypothyroid and required thyroxine. The discrimination of symptoms elicited by questionnaire compared favorably with that of interview symptoms. (BBB)

**17159** TOTAL AND HALF-BODY IRRADIATION: EFFECT ON COGNITIVE AND EMOTIONAL PROCESSES. Gottschalk, Louis A. (Univ. of California, Irvine); Kunkel, Robert; Wohl, Theodore H.; Saenger, Eugene L.; Winget, Carolyn N. Arch. Gen. Psychiat.; 21: 574-80(Nov 1969).

The acute mental reactions of patients with metastatic neoplasms exposed to whole-body irradiation or partial-body irradiation are described. The 16 patients with metastatic carcinoma were given whole-body or half-body irradiation as palliative treatment at doses ranging from 50 to 300 R by a $^{60}Co$ teletherapy unit. On nine patients for whom data were complete, evidence of transient impairment of intellectual function appeared immediately after actual irradiation and persisted one day later, using the criterion of an intellectual impairment scale applied to the content of short samples of speech. A lack of statistical significance between sham and actual radiation effects raised a question whether actual radiation verbal symbolic effects were, indeed, more pronounced that sham radiation effects. No evidence of a worsening of mentation was obtained with sham or actual radiation using different criteria of impaired intellectual function. A significant increase in pretreatment anxiety (but not in hostility) was found in the patients. Also, in 16 patients higher initial hope scores were associated with a shorter period of hospitalization and a longer survival time. (BBB)

## Radiation Effects on Plants

*Refer also to abstracts 16985, 17001, 17012, 17016, 17018, 17022–17026, 17028, 17029, and 17134.*

**17160** (STI/DOC–10/92) NEUTRON IRRADIATION OF SEEDS. PART II. Technical Reports Series No. 92. Second Report of an FAO/IAEA Meeting on Co-Ordination of Research Held in Vienna, December 11–15, 1967. (International Atomic Energy Agency, Vienna (Austria)). Oct. 1968. 183p. (CONF-671221). IAEA $5.00.

Eighteen individual papers are prepared. A program for seed irradiation with neutrons is presented and discussed. Various methods for dosimetry are investigated. Radioinduced mutations in seeds of various plants are studied. (H.B.G.)

*For abstracts of individual papers see: 16893–16896, 17022–17026, 17047, and 17161–17168.*

**17161** RESPONSE OF SEEDS TO IRRADIATION WITH X-RAYS AND NEUTRONS OVER A WIDE RANGE OF DOSES. Smith,

H. H.; Combatti, N. C.; Rossi, H. H. (Brookhaven National Lab., Upton, N. Y.). pp 3-8 of Neutron Irradiation of Seeds. Pt. II. Vienna; International Atomic Energy Agency (1968).

From FAO/IAEA Meeting on Co-ordination of Research on the Use of Neutrons in Seed Irradiation, Vienna, Austria. See STI/DOC-10/92; CONF-671221.

Two basic problems in radiobiology are: the relative biological effectiveness (RBE) of radiations of different quality, and the relation of genetic damage to cell lethality. Both can be investigated simultaneously by irradiation of appropriate genetic stocks. Seeds of $\underline{Y_{g_2}}/\underline{Y_{g_2}}$ maize irradiated with fission neutrons or 250-kVp x-rays were scored for plant response on the basis of nine criteria. These ranged from sublethal genetic damage ($\underline{y_{g_2}}$ sectors) to gamete lethality (reduction in seed set and pollen fertility), to selective somatic cell injury (reduction in plant height, survival and emergence), to complete cessation of cell division (reversal in emergence and plant height). The doses spanned four orders of magnitude for fission neutrons: 68 to 24,000 Rad. With the increasing doses required to produce these effects, the RBE decreased steadily from 75 to 3. A logarithmic plot of the neutron dose (N) versus the x-ray dose (X) for the nine equal effects can be fitted to the straight line: $\log N = -2.6 + 1.95 \log X$. Maintenance of the same simple power relation of X to N throughout the range implies: that the fundamental action of the radiations is on the same entity, that increasing injury is attributable mainly to quantitatively more chromosome breakage and loss, and that neutron-induced damage increases linearly with dose, while x-ray-induced damage increases as the square (slope = 1.95) of the dose. (auth)

**17162** GAMMA AND FISSION NEUTRON IRRADIATION OF GOSSYPIUM $F_1$ SEED. EFFECTS OF MOISTURE AND RADIATION ON SURVIVAL, YIELD, AND LOSS OF MARKER LOCI. Constantin, M. J. (UT-AEC Agricultural Research Lab., Oak Ridge, Tenn.). pp 29-38 of Neutron Irradiation of Seeds. Pt. II. Vienna; International Atomic Energy Agency (1968).

From FAO/IAEA Meeting on Co-ordination of Research on the Use of Neutrons in Seed Irradiation, Vienna, Austria. See STI/DOC-10/92; CONF-671221.

Hybrid seed of Gossypium hirsutum L. were moisture equilibrated at 0, 35, 60, and 85% RH and then exposed to 10, 20, 30, or 40 kRad of gamma rays from $^{137}Cs$ or 0.7, 1.4, 2.1, or 2.8 kRad of unmoderated fission neutrons. Plants from nonirradiated seed were grown for comparison. Spaced plants were field-grown to maturity and data were collected on survival, yield of seed cotton, and the loss of marker traits. Moisture content at time of seed irradiation influenced survival to maturity in the gamma but not in the neutron irradiated population. Moisture did not influence yield of seed cotton in either of the irradiated populations. There was an interesting tendency toward an increase mutation frequency as moisture was increased; however, the increase was not significant at P = 0.05. A dose effect was evident at all end-points. $D_{50}$ gamma rays varied from approximately 10 kRad at 3.4% to over 35 kRad at 11.1% moisture, whereas $D_{50}$ neutrons was slightly over 2 kRad for survival to maturity. Yield of seed cotton was relatively sensitive with $D_{50}$ gamma rays being 28 kRad and $D_{50}$ neutrons being 1 kRad. Per cent mutants among survivors increased linearly with radiation dose; the slope of the regression line was considerably steeper for neutrons than for gamma rays. Rad for Rad the neutrons were considerably more effective than gamma rays for all end-points. (auth)

**17163** EFFECTS OF OXYGEN AND MOISTURE CONTENT ON THE RADIATION DAMAGE IN BARLEY SEEDS IRRADIATED WITH FAST NEUTRONS AND GAMMA RAYS. Ahnstroem, G. (Stockholm Univ., Sweden). pp 43-8 of Neutron Irradiation of Seeds. Pt. II. Vienna; International Atomic Energy Agency (1968).

From FAO/IAEA Meeting on Co-ordination of Research on the Use of Neutrons in Seed Irradiation, Vienna, Austria. See STI/DOC-10/92; CONF-671221.

In gamma-irradiated barley seeds the effect of moisture content seems to modify the oxygen effect. If gamma-irradiated seeds (4% $H_2O$ content) are soaked in oxygen-free water before being transferred to oxygenated water, the oxygen-sensitive centers decay. This decay rate is a function of temperature and is shown to be most likely due to how fast the target molecules are hydrated. When low moisture content seeds were irradiated with fast neutrons in the SNIF, a moisture content effect was also obtained. However, contrary to what was found with gamma-irradiated seeds, no effect of oxygen was obtained. This excludes the possibility that gamma-contamination caused the moisture content effect. A model explaining the difference between the effect of neutrons and gamma-rays, respectively, is discussed. (auth)

**17164** EFFECTS OF FAST NEUTRONS ON SEEDLING GROWTH AND METABOLISM IN BARLEY. Mikaelsen, K. (International Atomic Energy Agency, Vienna). pp 63-70 of Neutron Irradiation of Seeds. Pt. II. Vienna; International Atomic Energy Agency (1968).

From FAO/IAEA Meeting on Co-ordination of Research on the Use of Neutrons in Seed Irradiation, Vienna, Austria. See STI/DOC-10/92; CONF-671221.

Barley seeds irradiated with fast neutrons showed reduced $O_2$ uptake per lot of seeds compared with untreated controls, but no difference per mg of embryo protein-N. This signified that respiration per unit of active protoplasm was unchanged. Endosperm proteolytic activity and nitrogen transport to the embryo were unchanged, but embryonic protein synthesis was inhibited and nucleic acid synthesis was reduced. The relationship between seedling growth retardation and nucleic acid reduction is discussed. (auth)

**17165** COMPARATIVE GENETIC EFFECTS OF GAMMA RAYS AND NEUTRONS ON BARLEY SEEDS. Pereau-Leroy, P. (CEA, Centre d'Etudes Nucleaires, Cadarache, France). pp 71-8 of Neutron Irradiation of Seeds. Pt. II. Vienna; International Atomic Energy Agency (1968). (In French).

From FAO/IAEA Meeting on Co-ordination of Research on the Use of Neutrons in Seed Irradiation, Vienna, Austria. See STI/DOC-10/92; CONF-671221.

Dried barley seeds of the Piroline variety were exposed to gamma rays from a cobalt-60 source and to the neutron fluxes obtained in two installations yielding different spectra: the biological cell of the EL3 reactor, where the flux, coming from a uranium converter, consists mainly of fast neutrons; and in the pool of the low-power PEGGY reactor, where the flux against the core chimney is much more thermal in nature. Neutron flux was determined by biological dosimetry, measuring the reduction in the growth of the first leaf of seedlings grown from irradiated grain. The genetic effects of gamma rays and neutrons on chlorophyll mutations are studied by analyzing their incidence, spectrum and segregation ratios in the second and third generations. Statistical analysis of the results shows that the spectra of the main chlorophyll mutations (albina, viridis, xanta) do not differ significantly regardless of type of radiation. Similarly, the incidence of presumed mutations which occur in the second generation, only to disappear in the third, and that of new mutations appearing only in the third generation do not differ with the type of radiation. Finally, the proportion of mutations that segregate at a ratio 3:1 in the third generation is the same with neutrons and gamma rays. This suggests that the proportion of significant chromosome modifications capable of being transmitted after meiosis and fertilization does not differ with the type of radiation applied to seeds of diploid species. (auth)

**17166** EFFECT OF FAST NEUTRONS AND GAMMA RADIATION ON SEEDLING AND ROOT GROWTH OF BARLEY VARIETIES. Mikaelsen, K.; Brunner, H. (International Atomic Energy Agency, Vienna). pp 79-82 of Neutron Irradiation of Seeds. Pt. II. Vienna; International Atomic Energy Agency (1968).

From FAO/IAEA Meeting on Co-ordination of Research on the Use of Neutrons in Seed Irradiation, Vienna, Austria. See STI/DOC-10/92; CONF-671221.

Seven varieties of barley were irradiated with 10 to 80 kRad of gamma rays and 0.3 to 1.2 kRad of fast neutrons. Their radiosensitivity was compared on the basis of 50% reduction in seedling and root growth. The RBE (ratio: gamma/neutron, 50% growth reduction dose) for roots was twice as high as for seedling growth reduction. (auth)

**17167** EXPERIENCE WITH THE STANDARD NEUTRON IRRADIATION FACILITY IN THE ASTRA REACTOR. Burtscher, A. (Oesterreichische Studiengesellschaft fuer Atomenergie G.m.b.H., Reaktorzentrum, Seibersdorf, Austria). pp 97-106 of Neutron Irradiation of Seeds. Pt. II. Vienna; International Atomic Energy Agency (1968).

From FAO/IAEA Meeting on Co-ordination of Research on the Use of Neutrons in Seed Irradiation, Vienna, Austria. See STI/DOC-10/92; CONF-671221.

During the past year, seed irradiations and dose measurements were performed in the standard neutron irradiation facility at the ASTRA reactor. The following special topics connected with irradiation of seeds and with neutron dosimetry are discussed. Variation of fast neutron flux in the seed irradiation facility during extended shift operation of the reactor; possible sources of errors in the determination of the conversion factor between neutron dose and fast neutron fluence; comparisons of the desired dose values with the ones measured with sulfur pellets during routine seed irradiations; limitations of spectral indices measurement using in-core irradiations as a fission-flux reference; experience gained with an improved sample container; and maximum permissible sample sizes for uniform irradiation. (auth)

17168 INVESTIGATIONS ON THE ENERGY DEPENDENCE OF THE BIOLOGICAL ACTION OF FAST NEUTRONS. Glubrecht, H.; Hamann, H. J. (Technische Hochschule Hannover, W. Ger.). pp 131-6 of Neutron Irradiation of Seeds. Pt. II. Vienna; International Atomic Energy Agency (1968).

From FAO/IAEA Meeting on Co-ordination of Research on the Use of Neutrons in Seed Irradiation, Vienna, Austria. See STI/DOC-10/92; CONF-671221.

A comparison was made between the action of 3.4-MeV and 14.7-MeV monoenergetic neutrons in four biological materials, namely: seeds of Hordeum vulgare and of Vicia faba, and spores of Aspergillus niger and Funaria hygrometrica. The neutrons were produced by the reactions $^{2}H(d,n)^{3}He$ and $^{3}H(d,n)^{4}He$ using a 600-keV cascade accelerator. Biological response was measured in terms of seedling growth, frequency of chromosome aberrations, or per cent survival. Dose response was compared for the two neutron energies and was found to differ significantly among the biological materials. The ratio of the radiation efficiency at the neutron energies did not agree with the value given by the conventional quality factors. (auth)

17169 EFFECTS OF FAST NEUTRON VERSUS X-IRRADIATION ON DEVELOPMENT, DIFFERENTIATION, AND PEROXIDASE ISOZYMES IN A GENETICALLY TUMOROUS NICOTIANA AMPHIPLOID AND ITS PARENTS. Conklin, M. E. (Adelphi Univ., Garden City, N. Y.); Smith, H. H. Int. J. Radiat. Biol.; 16: 311-21(1969).

The relative biological effectiveness of fast (fission) neutrons versus 250 kVp x rays was determined for three genotypes—Nicotiana suaveolens, N. langsdorffii, and their tumor-prone amphiploid—on the basis of four criteria: cotyledon emergence, leaf development, tumorization, and peroxidase isozymes. These very different responses monitored a range of absorbed doses; and the magnitude of the RBE values, which varied from 3.9 to 14.3, was inversely related to dose. This relationship could be expressed by the linear regression $\log N - 1.4 + 1.3 = \log X$, the significance of which is discussed. None of the dose-response curves was exponential; the slope of the linear part was related to interphase chromosome volume. (auth) (UK)

17170 INFLUENCE OF SODIUM CHLORIDE ON THE SURVIVAL OF IRRADIATED YEAST CELLS. Kabakova, N. M.; Kapul'tsevich, Yu. G. (Inst. of Medical Radiology, Obninsk, USSR). Radiobiologiya; 9: 892-6(Nov-Dec 1969). (In Russian).

It was shown that the survival of irradiated diploid yeast cells decreases in comparison with the initial value, if they are grown on nutrient medium containing NaCl. The salt influences the survival rate of such cells even after the realization of potential damages. Consequently, this modification of the survival is not associated with a suppression of recovery. The survival rate of haploid cells is reduced under the influence of NaCl regardless of the irradiation dose. These facts permit the assumption that certain sublethal damages to diploid cells become lethal when the cells are grown on salt medium. (tr-auth)

17171 CHANGE IN THE RADIOBIOLOGICAL EFFECT IN THE CASE OF STORAGE OF AIR-DRIED SEEDS IRRADIATED WITH PROTONS AND GAMMA-RAYS. Nevzgodina, L. V.; Pap'yan, N. M. (Inst. of Medicobiological Problems, Moscow). Radiobiologiya; 9: 888-91(Nov-Dec 1969). (In Russian).

During the storage of irradiated seeds of Brassica oleracea and Lactuca sativa, a change in the radiobiological effect was observed. An increase in the postradiation effect in $\gamma$-irradiated cabbage seeds was evident while in stored lettuce seeds, however, the initial radiobiological effect was aggravated by subsequent storage in the case of irradiation with both $\gamma$ rays and protons. (tr-auth)

17172 EFFECTS OF GAMMA RADIATION OF SPORES OF ASPERGILLUS FLAVUS ON PRODUCTION OF AFLATOXIN $B_1$. Jemmali, Mongi; Guilbot, Andre (CERDIA, Paris). Compt. Rend., Ser. D; 269: 2271-3(3 Dec 1969). (In French).

Toxinogenic and non-toxinogenic cultures of Aspergillus flavus were given 10 to 500 Krad of $^{60}Co$ $\gamma$ radiation. Sterile substrate was inoculated with the spores and incubated for seven days at 30°C and 95% relative humidity. Doses of 100 to 150 Krad resulted in maximal production of aflatoxin, while the production of aflatoxin was reduced by doses greater than 200 Krad in the toxinogenic cultures. No toxicity was detected in the irradiated non-toxinogenic cultures. It was concluded that $\gamma$ radiation induces or augments the production of aflatoxins in doses of less than 200 Krad. Therefore, doses of 70 Krad that have been considered for disinfection of cereals contaminated with Aspergillus spores could result in an increase in toxicity. However, irradiation of the contaminated cereal at higher doses could be an effective means of reducing the production of aflatoxins. (H.L.W.)

# Radiation Effects on Microorganisms

*Refer also to abstracts 16992, 16996–17000, 17031, 17032, 17037, 17038, and 17168.*

17173 EFFECT OF UV-IRRADIATED DNA CONTAINING 5-BROMOURACIL ON REACTIVATION OF UV DAMAGE IN PHAGE λ. Yan, Y. (Kyoto Univ.). Int. J. Radiat. Biol.; 16: 367-76(1969).

Reactivation of uv irradiated phage λ was investigated in vivo using two types of host cell: bacteria whose thymine of DNA has been replaced by 5 bromouracil (BU) (BU-cell) and followed by uv irradiation; and those multiple-infected with heavily uv irradiated λ containing BU (BU-λ). The uv-inactivation rate of λ in uv irradiated BU-cells was higher than that in unsubstituted control cells exposed to the same uv dose. The intracellular growth of uv-inactivated λ in irradiated BU-cells was markedly delayed, compared with that in irradiated control cells. The enhanced rate of uv inactivation of λ and the growth delay of λ were also observed in the host superinfected with heavily irradiated BU-λ. The results suggest that the presence of uv irradiated BU-DNA reduces HCR of uv damages in the phage λ. (auth) (UK)

17174 EFFECT OF PRE-IRRADIATION CONDITIONS ON RADIOSENSITIVITY AND REPAIR MECHANISMS IN ESCHERICHIA COLI K-12. Fry, John Christopher. Cardiff, Wales; University College of South Wales and Monmouthshire (1969). Thesis.

Investigations were made into the patterns of radioresistance encountered in survival curves of E. coli K-12 grown aerobically on a variety of simple and complex media, with and without the addition of glucose. Survival curves were obtained using plate counting and liquid recovery methods. It was shown that all cells recovered in liquid media appeared more radioresistant than those recovered on simple media. Mathematical analysis of the survival curves and assessment of the size and macromolecular composition of the irradiated cells, indicated that differences in the survival curves on solid media were attributable to variation in the repair ability of cells grown on different pre-irradiation media. With both solid and liquid recovery, increased complexity of the recovery medium enhanced the radioresistance of the organism. Recovering cells on both solid and in liquid media showed a variety of changes during the recovery period. Growth curves in liquid media were multiphasic, as were those on solid media. There was an initial period of mass increase during which long cell formation began and viability dropped. The length of this period depended on the recovery medium used. This was followed by a lytic phase during which nucleic acid fragments were released from the lysing cells and were taken up by the recovering cells. There was then a phase of survivor overgrowth during which no extra recovery occurred, but which represented a take over of a previously mixed population of cells by viable survivors. There was no sign of mitotic delay in recovering cells. It was suggested that the survival curves obtained by the standard liquid culture recovery method are not accurate representations of the actual liquid survival, owing to errors in the doubling time of survivor overgrowth and consequently the estimated survivor populations. Evidence was given for the true doubling times at this stage of recovery that indicated that survival in liquid medium was either similar or less than survival on solid medium. Evidence that the reduced survival in liquid medium was caused by the close proximity of the recovering cells was obtained from two methods of assaying survival on agar with closely packed cell populations. One method involved the counting of micro-colonies on agar with phase contrast microscopy, the other involved plotting growth curves on agar by the agar-wash technique and subsequent extrapolation of the phase of survivor overgrowth to obtain an estimate of survival. (auth) (UK)

17175 PROBLEMS AND RESULTS OF VACUUM TREATMENT OF BIOLOGICAL OBJECTS. Buecker, H.; Horneck, G.; Weber, W. J. (Univ., Frankfurt am Main). Vakuum-Tech.; 18: 217-20(Nov 1969). (In German).

It seems necessary to carry out experiments on biological objects in vacuum for solving some essential problems of biophysics, as well in space research as in basic research. The effect of high vacuum up to $10^{-5}$ Torr was investigated on the bacterium Escherichia coli B/r under various conditions, i.e., at different temperatures, with protecting substances, and combined with uv- or x-irradiation. It was shown that the damage of the bacteria depends on water desorption of the sample. As to irradiation with x-rays or uv during vacuum exposure the radiation sensitivity of the object was much higher than at atmospheric pressure. Further experiments are planned in the ultrahigh vacuum range. The requirements for a system allowing biological investigations in ultrahigh vacuum are discussed. (auth)

17176 NONGENETIC REACTIVATION OF FROG POLYHEDRAL CYTOPLASMIC DEOXYRIBOVIRUS (PCDV). Gravell, Maneth; Naegele, Robert F. (St. Jude Children's Research Hospital, Memphis. Univ. of Tennessee Medical Units, Memphis). Virology; 40: 170-4(Jan 1970).

The nongenetic reactivation of frog polyhedral cytoplasmic deoxyribovirus (PCDV) was demonstrated by plaque assay in cultured fathead minnow epithelial cells (FHM). Samples of wild-type PCDV (PCDV+) were inactivated by heat or uv irradiation. Cultures of FHM were infected with either a combination of heat- and uv-inactivated virus or singly infected with heat-inactivated, uv-inactivated, or noninactivated virus. An approximately 16-fold increase in virus titer over background was obtained from cultures mixedly infected with heat- and uv-inactivated PCDV+. The background virus titer from cultures singly infected with heat- or or uv-inactivated virus were, respectively, 100- and 1000-fold less than from mixedly infected cultures. The higher background virus titers were believed to result from reactivation of residual heat-inactivated virus during the plaque assay procedure. Using uv-inactivated PCDV+ and heat-inactivated ts-150, a temperature-sensitive mutant that plaques efficiently at 25° but not at 30°, it was shown that progeny virus bear the genotype of the protein-inactivated parent. Substitution of urea-inactivated rather that heat-inactivated PCDV confirmed this conclusion. Two hypotheses for this phenomenon, both having direct bearing on the two-stage poxvirus uncoating mechanism, are discussed. (E.R.B.)

17177 INDUCTION OF VIRUS SYNTHESIS IN POLYOMA TRANSFORMED CELLS BY ULTRAVIOLET LIGHT AND MITOMYCIN C. Fogel, Marian; Sachs, Leo (Weizmann Inst. of Science, Rehovot, Israel). Virology; 40: 174-7(Jan 1970).

Experiments were conducted to determine whether polyoma virus (PV)-transformed cells could be induced to synthesize virus by uv irradiation or treatment with mitomycin C (MC). Whether clones with or without spontaneous induction could be induced by MC and whether there could be a conversion of clones from MC-inducible to MC-noninducible were also investigated. The results indicated that uv irradiation and MC induced the synthesis of infectious virus in both clones studied. In both cases, the amount of virus synthesized was dose dependent. Eighty-three percent of the second-generation clones isolated from the two clones used, showed spontaneous induction of virus synthesis in about 1 in 104 cells. These clones were used to determine the frequency of clones with or without spontaneous induction that can be induced by MC. The results indicated that all of the clones with spontaneous induction and 50% of the clones without spontaneous induction were inducible by MC, and that there can be a conversion of clones from MC-inducible to MC-noninducible. The reverse conversion in these clones occurred only at a very low frequency. (E.R.B.)

17178 INACTIVATION OF INFLUENZA VIRUS BY GAMMA RADIATION. Pleceas, M.; Arizan, D.; Hlevca, B. Stud. Cercet. Inframicrobiol.; 19: 425-7(1968). (In Rumanian).

The inactivating effect of γ radiation ($^{60}$Co) on the influenza virus PR-8 in normal saline solution is reported. The virus was totally inactivated following irradiation with a dose of 2,000,000 R/gm. (Rom. Sci. Abstr.) (auth)

17179 THE ACTION OF γ RADIATION ON MEASLES VIRUS. Sorodoc, Y.; Cepleanu, M.; Burducea, O.; Cernescu, C. Stud. Cercet. Inframicrobiol.; 19: 437-40(1968). (In Rumanian).

Under the action of γ radiation delivered in doses of $\leq 5 \times 10^5$ R ($^{60}$Co) the infectivity of the autochthonous measles virus MN strain (non-purified) was destroyed. The hemagglutinating titre of the strain was influenced by doses in the range of $1 \times 10^5$ to $2 \times 10^6$ R. (Rom. Sci. Abstr.) (auth)

17180 RADIATION TREATMENT OF FOODS. II. PUBLIC HEALTH SIGNIFICANCE OF IRRADIATION-RECYCLED SALMONELLA. Epps, N. A.; Idziak, Edmund S. (McGill Univ., Montreal). Appl. Microbiol.; 19: 338-44(Feb 1970).

Strains of Salmonella typhimurium resistant to γ irradiation were developed by repeated irradiation and subculturing in a nutrient broth-yeast extract medium. Few differences were noted in the biochemical characteristics of parent and resistant cultures; however, microculture studies revealed variations in morphology and in cell division patterns. A considerable decrease in pathogenicity for day-old chicks was apparent with resistant cultures, but their phenol-water extracts were as toxic as parent material for 10-day chick embryos. Five serial chick passages did not reverse the reduced pathogenicity or aberrant morphology of a resistant S. typhimurium culture. Results of phage typing of both parent and serially irradiated S. typhimurium were inconclusive, whereas the O-1 genus-specific phage lysed all parent serotypes tested but only one of the serially irradiated cultures. Agglutination of parent S. typhimurium cells with their homologous rabbit antiserum was unaffected by prior absorption with resistant strains. The results indicate that radiation recycling altered Salmonella into strains of lesser public health significance. (auth)

17181 INFLUENCE OF DIMETHYL SULFOXIDE (DMSO) ON CONIDIAL PIGMENTATION AND CONSEQUENT UV LIGHT SENSITIVITY OF AFLATOXIN PRODUCING STRAINS OF ASPERGILLUS FLAVUS. Bean, G. A.; Rambo, G. W.; Klarman, W. L. (Univ. of Maryland, College Park). Life Sci.; 8: 1185-91(15 Nov 1969).

The influence of DMSO and other compounds on the pigmentation of conidia of the aflatoxin-producing fungus A. flavus and the effect of a loss of pigmentation on germination of the conidia were studied. The effect of uv light on spore germination was determined by exposing them to a General Electric G15T8 germicidal lamp (2537 Å) held 6 in above the spores. The irradiated spores were incubated in total darkness for 24 hr after which percentages of germinated spores were determined by microscopic examination. A concentration of 2500 ppM DMSO caused the first noticeable decrease in conidial pigmentation, and a further decrease in intensity of pigmentation resulted from increased concentrations of DMSO. Fungi grown on medium containing 10,000 ppM DMSO produced completely nonpigmented (white) conidia which remained nonpigmented until the fungus was transferred to DMSO-free medium. Levels of 25,000 and 50,000 ppM DMSO caused a slight reduction of growth of A. flavus. To test uv sensitivity of pigmented and nonpigmented conidia, A. flavus conidia were irradiated for various lengths of time up to a maximum of 45 sec exposure. The percentage germination of both pigmented and nonpigmented conidia decreased equally with increased exposure to uv light up to 20 sec. Exposures of 20 sec or more caused much greater decrease in germination in nonpigmented than in pigmented spores and with 30 sec exposure, 30% of the pigmented conidia germinated whereas none of the nonpigmented conidia germinated. With 45 sec irradiation, none of the conidia germinated. (BBB)

17182 IN VIVO SUPPRESSION OF CODING ASSOCIATED WITH BACTERIOPHAGE-INDUCED S-ADENOSYLMETHIONINE HYDROLASE. Siersma, P. W.; Lederberg, S. (Brown Univ., Providence). J. Bacteriol.; 101: 398-407(Feb 1970).

The methylation of ribosomal and transfer ribonucleic acid (RNA) synthesized after the induction of a hydrolase for S-adenosylmethionine by phage T3 infection is reducible to 50% of the methylation of RNA in uninfected cells. Hypomethylated ribosomal RNA is found in 70S particles that dissociate in 100 μM $Mg^{++}$ to yield only 30S and 50S subunits. By this criterion, the omitted methyl groups apparently are not required for ribosomal maturation or stability. The rate of production of alkaline phosphatase in a phosphatase amber mutant was examined after phage infection in the presence and in the absence of streptomycin to determine the effect on the translation process consequent to S-adenosyl-L-methionine (SAM) hydrolase induction. Significant increases in the rates of phosphatase production were found when uv-inactivated T3 or streptomycin was added. The effects were cumulative when the cells were treated with both bacteriophage and the drug. Ultraviolet-inactivated T7, a phage closely related to T3 but which does not produce the SAM hydrolase, did not enhance the rate of alkaline phosphatase production. It is suggested that the production of SAM hydrolase affects the stability of the translation process by the observed hypomethylation or by mechanisms concerning polyamine metabolism. (auth)

17183 REPRESSION OF INDUCTION BY U. V. OF λ PHAGE BY exrA MUTATIONS IN ESCHERICHIA COLI. Donch, John; Greenberg, Joseph; Green, Michael H. L. (Palo Alto Medical Research Foundation, Calif.). Genet. Res.; 15: 87-97(Feb 1970).

The effect of uv radiation on λ lysogens of exrA strains of Escherichia coli was studied. exrA strains could be lysogenized with, as well as support the vegetative reproduction of, λ. However, though spontaneous induction of λ occurred in exrA(λ) strain at 10% the frequency of $exrA^+(\lambda)$ strain, exrA(λ) strains were not induced by uv. Because λ was not induced in exrA(λ) strains, lysogens of these strains were no more sensitive to uv than were non-lysogens. The heat-inducible mutant λhcI857 could be induced in exrA strains at elevated temperatures. Furthermore, uv irradiation of exrA(λhcI857) strain did not prevent the heat induction of this λ mutant. The exrA mutation appeared to interfere only with the inactivation of λ repressor by uv irradiation. Among the exrA strains studied was strain Bsl(exrAuvrB). Whereas the λ lysogen of strain Bsl could not be induced by uv and was no more sensitive to uv than its non-lysogen, the $exrA^+uvrB(\lambda)$ derivative of strain Bsl could be induced by uv and was more sensitive to uv than its non-lysogen. (auth)

# Radiosterilization and Radiopreservation

*Refer also to abstracts 16969, 17180, and 18564.*

17184 (NYO-3461-3) THE DETERMINATION OF THE WHOLESOMENESS OF IRRADIATION PASTEURIZED CLAMS. Final Summary for the Period Through August 1968. Reber, Elwood F. (Massachusetts Univ., Amherst. Dept. of Food and Nutrition). Contract AT(30-1)-3461. 88p. Dep. CFSTI.

Two separate abstracts were prepared for the two parts of this final summary of the project on the determination of the wholesomeness of irradiation-pasteurized clams. (C.O.)

*For abstracts of individual sections see: 16969 and 17185.*

17185 (NYO-3461-3, Paper 1) EFFECT OF THIAMINASE ON RATS FED NON-RADIATED AND RADIATED CLAMS. Kuo, Guei-ru (Massachusetts Univ., Amherst. Dept. of Food and Nutrition). 45p.

Thesis.

This investigation was conducted to determine the protein quality of non-radiated thiaminase-active clams (Mya arenaria) and that of thiaminase-active clams radiated at the 0.4 and 0.8 megarad levels with $^{60}Co$ $\gamma$ rays, to find out whether 2 mg thiamine · HCl per 100 ml of drinking water are sufficient to prevent thiamine deficiency caused by thiaminase activity in clams and to determine the thiaminase activity in nonradiated, 0.4 megarad radiated, and 0.8 megarad radiated clams. It was established that the protein quality of radiated clams was significantly ($P < 0.01$) lower than that of non-radiated clams and was equal to that of casein. Drinking water containing 2 mg of thiamine · HCl per 100 ml was found to prevent erythrocyte transketolase activity in rats consuming thiaminase-active clams from falling below its normal value. Therefore, no thiamine deficiency occurred in these rats. In the course of this investigation, an improved method of determining thiaminase activity in marine products was developed. This method was used to show that thiaminase activity in clams decreased as radiation dosage increased. (auth)

17186 TURKISH GRAIN IRRADIATOR. Campbell, P. L. Consult. Eng.; 32: 46-7(Nov 1968).

The first commercial grain irradiation plant was constructed adjacent to a large existing grain silo at the Port of Iskenderun in south east Turkey. It consists of a tower 5.6m square and 31.46m in height. The lower section houses the irradiator and above this are situated two bins, each of 125 ton capacity, with a perforated diaphragm. Grain irradiation eradicates all the insects which can potentially cause deterioration and the grain can be stored safely. Extensive research has led to the firm belief that the effect of the irradiation will not be injurious to people who later consume the irradiated grain. The nature of the project that was commissioned by the IAEA is described. (auth) (UK)

17187 PHYSIOLOGICAL STUDIES OF GAMMA IRRADIATED TOMATO FRUITS. I. EFFECT ON RESPIRATORY RATE, ETHYLENE PRODUCTION, AND RIPENING. Abdel-Kader, Adel S.; Morris, Leonard L.; Maxie, E. C. (Univ. of California, Davis). Contract UCD-34P80. Proc. Amer. Soc. Hort. Sci.; 92: 553-67(1968).

Gamma irradiation induced an immediate stimulation in respiratory rate of tomato fruits with the magnitude and duration of the response increasing with dose. Doses of 600 Krad or more depressed, and less than 500 Krad stimulated, ethylene ($C_2H_4$) production by the fruits. Stimulation of $C_2H_4$ production was not accompanied by an increase in the ripening rate of the fruit. Inhibition of color development by irradiation was less with advanced fruit maturity at time of treatment. Mature green fruits subjected to 500 or more Krad and pink fruits subjected to 600 or more Krad failed to reach table-ripeness. Color development was abnormal in fruits subjected to 500 or more Krad and this effect was most striking in mature-green fruits. (auth)

17188 WORLDWIDE OUTLOOK FOR FOOD IRRADIATION. MacQueen, K. F. (Atomic Energy of Canada Ltd., Ottawa). pp 207-17 of The International Conference on Constructive Uses of Atomic Energy. /Farmakes, Ruth (ed.). Hinsdale, Ill.; American Nuclear Society (1969).

From International Conference on the Constructive Uses of Atomic Energy, Washington, D. C. See CONF-681101.

Radiation treatment produces many useful effects that could benefit the production, preservation, and distribution of food. Research conducted in many countries has shown that radiation can stimulate growth of certain crops to achieve earlier maturity and higher yields; can inhibit sprouting in root crops; can destroy insects that infest grain products and dried foods; can extend the shelf life of fresh fruits, fish, and meats; can eliminate food-poisoning organisms from various products; and can sterilize foods to achieve long storage without refrigeration. Radiation has a unique contribution to offer as a processing technique, and can be applied to a wide spectrum of food products. Radiation offers the distinct advantage that it can be applied after final packaging, regardless of the packaging material used. Radiation also offers possibilities of being applied as a public health measure to render some foods free from the hazards associated with food-poisoning microorganisms or parasites. The radiation technology of equipment design and development is well advanced and presents no barrier to future developments in food irradiation. Irradiators have been designed and operated to serve a variety of purposes in both research and pilot-plant programs. With about 50 countries reporting some research activity on irradiated foods, there is an indication of great interest being displayed on an international scale. There is no question but that radiation is becoming a recognized technique for tackling problems associated with the conservation and distribution of world food supplies. The optimum benefits of radiation will most often be realized when radiation is used in conjunction with other modern techniques such as proper packaging, better storage facilities, and improved transportation and distribution methods. The greatest barrier to achieving commercial adoption of food irradiation at this time is, most likely, the small number of clearances that are available today on a worldwide basis. An increase in the number of clearances available in countries with sizable programs and an increase in the numbers of countries providing clearances would stimulate more active participation by the food industry and by developing nations. The food industry is mainly interested in new processes that have been cleared by the health authorities. The developing countries and smaller nations generally are looking to the developed countries for leadership to undertake the expensive testing that will lead to clearances for irradiated foods. With continued support and effort, many more clearances will be available within the next several years and some real progress towards commercialization of the process will be achieved. There is good reason to be encouraged by the efforts that have been expended on food irradiation by dedicated investigaters working in many countries, and we can look forward to the day when this new technology will be widely applied as a method to improve the preservation, safety, and distribution of world food supplies. (auth)

# METALS, CERAMICS, AND OTHER MATERIALS

## Metals and Alloys

*Refer also to abstracts 16623 and 18587.*

17189 (IN-1335) REACTOR ENGINEERING BRANCH ANNUAL REPORT, FISCAL YEAR 1969. Covington, E. D. (ed.) (Idaho Nuclear Corp., Idaho Falls). Nov 1969. Contract AT(10-1)-1230. 106p. Dep. CFSTI.

Progress in research and development is summarized in four sections. A separate abstract was prepared for each section. (J.R.D.)

*For abstracts of individual sections see: 17330, 17392, 18715, and 18716.*

17190 (IS-2100) ANNUAL SUMMARY RESEARCH REPORT, CERAMIC AND MECHANICAL ENGINEERING, CHEMICAL ENGINEERING, CHEMISTRY, MATHEMATICS AND COMPUTER SCIENCE, METALLURGY, PHYSICS, AND REACTOR DIVISIONS, JULY 1, 1968-JUNE 30, 1969. (Ames Lab., Iowa). Jul 1969. Contract W-7405-eng-82. 386p. Dep. CFSTI.

Individual abstracts were prepared for six sections. The section dealing with mathematics and computer science was not abstracted and includes information on mathematics and programming research. (J.G.B.)

*For abstracts of individual sections see: 16485, 16623, 17191, 17357, 18097, and 18717.*

17191 (IS-2100, Sect. M) METALLURGY DIVISION. Hansen, R. S.; Smith, J. F.; Bailey, D. M.; (and others) (Ames Lab., Iowa). 88p.

Results of research are presented on metal preparation and purification for fuel cladding, phase studies of reactor metals, reactor materials development, materials properties at high temperatures, crystal plasticity, structures and properties of solids, diffusion and transport properties, properties of surfaces, and radiation damage in reactor materials. (J.R.D.)

17192 (ORNL-4480) FUELS AND MATERIALS DEVELOPMENT PROGRAM QUARTERLY PROGRESS REPORT FOR PERIOI ENDING SEPTEMBER 30, 1969. Patriarca, P. (comp.); Rucker, D. J. (ed.) (Oak Ridge National Lab., Tenn.). Feb 1970. Contract W-7405-eng-26. 314p. Dep. CFSTI.

Research progress on the development of fuels and materials is reported in twenty-five sections. A separate abstract was prepared for twenty-three sections. No abstracts were prepared for two short sections on the effects of power cycling on LMFBR fuel cladding behavior and technical assistance in the procurement of fuel elements. (R.C.K.)

*For abstracts of individual sections see: 16807, 16808, 17200-17202, 17227-17232, 17259, 17260, 17332, 17343-17345, 17393-17397, and 18655.*

17193 PRACTICAL FRACTURE MECHANICS FOR STRUCTURAL STEEL. Proceednings of Symposium on Fracture Toughness Concepts for Weldable Structural Steel. Dobson, M. O. (ed.). London; Chapman and Hall, Ltd. (1969). 105s. (CONF-690440).

Sixteen papers were presented at the conference. A separate abstract was prepared for each. (UK)

*For abstracts of individual papers see: 17279-17294.*

17194 CLADDING MATERIALS FOR FAST BREEDER REACTORS. Boehm, Horst (Kernforschungszentrums, Karlsruhe, Ger.). Atomkernenergie; 15: 14-18(1970). (In German). (CONF-690419-4).

From Reactor Meeting of the German Atomforum, Frankfurt am Main, Germany.

Among the different possible cladding materials for sodium cooled fast breeder reactors at present austenitic stainless steels show the best combination of mechanical properties, corrosion and irradiation behavior. It seems to be possible to improve their strength and irradiation behavior. Vanadium alloys, which have higher strength and better resistance to irradiation damage than austenitic stainless steels, may only be used as claddings if they don't lessen the economy of the reactor. Estimation results indicate that even under this condition the use of V-alloys seems to be possible provided that some properties are further improved. (auth)

17195 METALLURGY DEPARTMENT OF THE DANISH ATOMIC ENERGY COMMISSION RESEARCH ESTABLISHMENT RISOE. Hansen, Niels (Danish Atomic Energy Commission, Risoe). Forsk. Udvikling-Uddannelse (Copenhagen): 78: 322-6(1969). (In Danish).

The main activities within the fields of reactor technology, technological development, and basic research are described. The nuclear projects are fuel assemblies for MTR-reactors and water-cooled power reactors, reactor vessels in steel and concrete, post-irradiation examination of construction materials, and fuel elements. The non-nuclear projects are vacuum metallurgy, powder metallurgy, chemical and electrolytic surface treatment, and brazing. Development of new materials is carried out in cooperation with several foreign institutes. Basic research covers examination of physical, mechanical, and technological characteristics of ceramic and metallic materials, especially dispersion-strengthened and fiber-reinforced products. The educational activities of the laboratory consist of training of students and reception of research fellows. (auth) (Denmark)

### Corrosion and Erosion

*Refer also to abstracts 16545, 16548, 16733, 17249, 17357, and 18557.*

17196 (CEA-CONF-1377) STUDY OF THE CORROSION BEHAVIOR OF LIGHT ALLOYS IN THE NUCLEAR DOMAIN. Blanchet, J. (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). [1965]. 16p. (In French). (CONF-690628-1). Dep. CFSTI (U. S. Sales Only).

From Conference on Nuclear Corrosion, Paris, France.

The corrosion behavior of Al and Mg alloys in aqueous solution governs where these alloys can be used in the nuclear industry. In water below 150°C, the performance of A 5 (Al = 99.5%) aluminum alloy is satisfactory. Provided that certain precautions are taken e.g., chiefly high water purity, very low copper content, and high surface property of the metal, it can be used in swimming pool reactors. At temperatures higher than 150 to 200°C, the appearance of corrosion as hydrogen pressure sacs limits the use of aluminum: some alloys with additions of iron and nickel are capable of resisting corrosion in water up to 300°C. These alloys may be useful in high flux reactors. Magnesium presents certain behavior analogies with aluminum; however, its resistance to aqueous corrosion is much less because of the absence of the protective character of magnesium oxide. Consequently, the use of magnesium in water is reduced to the storage of fuel elements clad with this metal in deactivation pools. In this particular case, the medium in which localized attacks of the claddings can be avoided is defined. (tr-auth)

17197 (GEAP-5693) SODIUM COMPONENTS DEVELOPMENT PROGRAM MASS TRANSFER INVESTIGATION IN LIQUID METAL SYSTEMS. Quarterly Progress Report No. 6, June-August 1968. (General Electric Co., Sunnyvale, Calif. Advanced Products Operation). Oct 1968. Contract AT(04-3)-189. 92p. Dep. CFSTI.

Efforts devoted to determination of empirical and rational models for accurate prediction of corrosion and mass transport in primary and secondary systems of large reactor plant designs are summarized. Development efforts on sodium system sampling, analytical chemistry, and collection and identification of particulate material are reported. Efforts to ensure well controlled operation of loops and to support development of rational models are discussed. The effects on design properties of 2¼ Cr-1 Mo steel as a result of carbon transport in bimetallic systems were investigated. A review of available data and determination of test objectives and experimental requirements was conducted. Research on long term stress rupture to 10,000 hours, and stress fatigue data to 6,000 hours for LMFBR cladding candidates was continued. Efforts devoted to correlation of corrosion data from large sodium systems with predictions from previously developed corrosion models are discussed. (J.R.D.)

17198 (IFA-FR-74) RADIATION EFFECTS ON OXIDIZED FILMS PRODUCED ELECTROLYTICALLY. Alexan, Zamfira (Academia R. S. R., Bucharest. Institutul de Fizica Atomica). 1969. 4p. (In Russian). Dep. CFSTI (U. S. Sales Only).

Oxide films on aluminum metal were formed in an electrolytic cell with the use of 3, 5, 10, 20, and 30% $H_2SO_4$ solution, with 5% oxalic acid solution, and 3% $CrO_3$ solution. The oxide film thickness was determined gravimetrically by dipping the oxidized metal in a phosphoric acid solution (d = 1.52) at 80 to 100°C for 15 minutes in order to remove the oxide film. The film thickness varied

from 3 to 10 microns. An x-ray study of the oxide film formed in oxalic acid showed a cubic structure corresponding to the gamma form of aluminum oxide. The x-ray lines corresponded to those of a hydrated oxide. This study was preliminary to studies on corrosion in a field of radiation. (TTT)

17199 (JUL-608-RW) MOLTEN SALT BREEDER STUDIES. ANNUAL REPORT, 1968. MATERIALS INVESTIGATIONS. Ali Khan, I. (Kernforschungsanlage, Juelich (West Germany). Institut fuer Reaktorwerkstoffe). Jul 1969. 78p. (In German). Dep. CFSTI (U. S. Sales Only).

Within the framework of molten salt breeder studies, materials are investigated which are compatible with the liquid sodium coolant and with fluoride salt melts at high temperatures. Since the 16/13 and 18/10 chromium-nickel steels are compatible with liquid sodium at high temperatures, they are investigated further. They show, however, insufficient corrosion stability against fluoride salt melts. By addition of inhibitors in the molten salts the corrosion processes can be stopped in anisothermal circuit systems so that practically no corrosion occurs in the steels. A compilation is given of the studies carried out and the results obtained. Two purification devices for molten salt having capacities of about 2.5 and 10 kg and a hydrogen fluoride-hydrogen installation are in operation. Several anisothermal circuit systems, whose walls consisted of the material to be investigated were layered with fluoride salt melts of different composition. The studies on the corrosion behavior of the steels 4988, 4961, and 4571 with respect to a melt with 24% heavy metal content (76 mol% NaF - 12 mol% $ThF_4$ - 12 mol% $UF_4$) at 750°C gave a penetration depth of 70 $\mu$ in 4988 steel, 100 $\mu$ in 4571 steel, and 400 $\mu$ in 4961 steel. At 850°C the 4988 steel in this same salt melt was attacked more strongly (penetration depth of 1200 $\mu$) than the 4580 steel (penetration depth 610 $\mu$) than in a molten salt with higher UF concentrations. By addition of Ti + Mg and Mg inhibitors in the molten salt (76 mol% NaF - 12 mol% $ThF_4$ - 12 mol% $UF_4$ the corrosive attack on the steels 4988, 4961, and 4571 could be almost completely stopped at 750°C. Type 4580 steel was investigated in fluoride salt melts of various composition at 850°C with a temperature gradient of 170°C and exposure time of 1000 hrs; the effect of the salt composition on the corrosion behavior was monitored. With increasing $UF_4$ concentration in the molten salt, a greater corrosion attack on the steel was observed. Under 800°C the corrosion stability of steel was significantly improved by the formation of an inhibition layer of Nb on the surface. In pure Nb, the colder areas in the loop walls were attacked. Nb - 1Zr shows a better corrosion behavior than pure Nb. Crack-free Nb layers up to a thickness of 150 $\mu$ were galvanically deposited on 4580 steel. Under argon atmosphere the layers were stable up to 1000°C. (tr-auth)

17200 (ORNL-4480, pp 118-28) SODIUM CORROSION STUDIES. (Oak Ridge National Lab., Tenn.).

From Fuels and Materials Development Program Quarterly Progress Report.

A series of capsules were constructed for use in comparing the effects of O in Na on V and V alloys at 600°C. The alloys to be tested are V-5% Cr, V-10% Cr, V-15% Cr, V-20% Ti, V-15% Cr-5% Ti, Vanstar 7, Vanstar 8, and Vanstar 9. The alloys are being exposed to Na containing 2000 ppM O in capsules of type 304 stainless steel for 100, 200, 300, and 600 hr. A thermal convection loop with a surface area ratio of 1:4 of V to type 304L stainless steel was terminated after operating 3000 hr. Commercial and high-purity V specimens from dissimilar-alloy static capsules of type 304L stainless steel showed increases in C and N at 700 and 800°C (transfer was considerably greater at 800°C). Only the high-purity V increased in O. At 700°C, interstitial transport from type 321 stainless steel was negligible compared with that from type 304L stainless steel. The interstitial mass transport from the type 304L stainless steel led to reduced ductilities at room temperature for both grades of V, but there was no change in the tests with type 321 stainless steels. The rates of O contamination for unalloyed V were determined from 400 to 900°C for vacuum ($4 \times 10^{-8}$ torr) and $O_2$ pressures of $2 \times 10^{-8}$ and $2 \times 10^{-7}$ torr. The contamination rate goes through a maximum at about 550°C. Diffusion kinetics appear to control the rate below the maximum, and there is a decrease in the number of O atoms adsorbed above the maximum. The long-term studies (5000 hr) of the compatibility of thermal insulation with stainless steel were completed. Weight gain at 760°C showed that the scaling of type 316 stainless steel increased more between 1000 and 5000 hr in moist air than in dry air, and nearly the same scaling resulted at 760 and 730°C when the surfaces were prepared by machining or pickling. An apparatus designed to study the effect of Na on the oxidation of stainless steel was built, and the first tests are in progress. (auth)

17201 (ORNL-4480, pp 196-205) CORROSION STUDIES OF ADVANCED REFRACTORY METALS. (Oak Ridge National Lab., Tenn.).

From Fuels and Materials Development Program Quarterly Progress Report.

A series of thermal convection loop tests to evaluate the corrosion behavior of W and W-Re alloys in flowing Li at 1350°C are planned. Loops of unalloyed W and W-25% Re are now under construction. Improved techniques were developed for installing the W-Re thermocouples used in Li loops. This was necessitated by failures of both sheathed and bare-wire couples during a trial run of the T-111 pumped Li loop (FCLLL-1). Three types of couples are now being installed on the loop: W-Re wires contained in a Ta sheath; bare W-Re wires spot welded directly to the loop; and bare W-Re wires mechanically tied to the loop. Measurements of the coefficient for distribution of O between K and Zr, which heretofore had been impossible, were made by means of an improved method for determining the O content of the K. Fast-neutron activation analyses for O verified a prediction that the coefficient exceeded 1000. When a series of Nb specimens to which 300 to 1650 ppM O had been added were exposed to Li at 600°C, the threshold O concentrations for Li penetration were found to be 400 and 800 ppM O for intergranular and transgranular penetration, respectively. (auth)

17202 (ORNL-4480, pp 297-305) ADVANCED MATERIALS FOR STEAM GENERATORS. (Oak Ridge National Lab., Tenn.).

From Fuels and Materials Development Program Quarterly Progress Report.

The resistance of weldments between dissimilar metals to corrosion by steam at 595 and 650°C is being investigated. Measurements of the weight gained and the thickness of the scale formed by specimens showed good resistance for most weldments at both temperatures for times to 6000 hr. However, some spallation was noted in welds of the IN 102 alloy at 650°C. Stress-corrosion studies at the lower temperature for times to 4000 hr revealed no cracks or evidence of crack propagation that could be attributed to stress corrosion. (auth)

17203 (UCRL-19029) MEASUREMENT OF THE KINETICS OF OXIDATION OF MOLYBDENUM BY MEANS OF THE REACTING, ROTATING DISK TECHNIQUE. Schofill, John L. Jr. (California Univ., Berkeley. Lawrence Radiation Lab.). Nov 1969. Contract W-7405-eng-48. 137p. Dep. CFSTI.

Thesis.

A rotating disk system has been developed to study heterogeneous chemical reactions subject to gas phase diffusion limitations. The system has been operated at temperatures up to 2000°K and disk speeds up to 15,000 rpm to investigate the reaction of oxygen and molybdenum. The independence of reaction or diffusion on radial position in the rotating disk system permitted kinetic data to be obtained from simple weight loss measurements as a function of disk temperature, oxygen partial pressure, and disk speed. Because of the availability of an exact solution of the diffusion-convection equation for the rotating disk, the diffusional contribution to the overall rate can be accurately assessed when both diffusion and surface reaction offer resistances of comparable magnitude. The surface process was shown to be consistent with the overall reaction $Mo(s) + O_2(g) \rightarrow MoO_3(g)$. The order of this reaction with respect to oxygen partial pressures from 0.002 to 0.05 atm at one atmosphere total pressure was found to be 1.00 ± 0.03 and the activation energy of the reaction was determined as 40 ± 0.3 kcal/mole. Both figures apply to the temperature range 1100 to 1500°K. At temperatures above ~1650°K, the overall rate of corrosion was temperature independent, and predicted by rotating disk theory to within 15%. The results of this study have demonstrated the importance of studying heterogeneous reactions at atmospheric pressure and high temperature in a flow system for which accurate prediction of diffusional limitations is possible. The rotating disk is an eminently satisfactory tool for such theoretical and experimental studies. (auth)

17204 METHOD OF INHIBITING THE CORROSION OF TANTALUM BY LIQUID LITHIUM AT HIGH TEMPERATURES. Wang, James Y. N. (to United States Atomic Energy Commission). U. S. Patent 3,494,805. 10 Feb 1970.

A method is described for inhibiting the corrosion of tantalum by liquid lithium at high temperatures comprising adding 0.15 to 1.5 at. % silicon to the lithium and contacting the tantalum with the lithium at temperatures above 1000°C. (AEC)

17205 EFFECT OF WATER VAPOR ON THE COMBUSTION OF FLASH-HEATED BERYLLIUM DROPLETS. Prentice, Jack L. (Naval Weapons Center, China Lake, Calif.). J. Electrochem. Soc.; 117: 385-7(Mar 1970).

Experiments are described in which each Be particle, nominally 500 $\mu$ in diameter, was ignited by exposing a small square of Be foil to the thermal pulse from a high-intensity Xe flash discharge lamp. The droplets fell freely in a glass reaction vessel containing an oxidizer and provided with a quartz flash lamp. The ignited spherical particles were quenched and studied by electron microscopy. Results of the experiments are analyzed and are illustrated by micrographs. (J.R.D.)

17206 THE EFFECT OF STRESS ON THE LOW-TEMPERATURE OXIDATION OF NIOBIUM. Weirick, Lawrence John. Ames, Iowa; Iowa State Univ. (1969). 243p.

Thesis.

A lateral compressive stress of about 94,000 psi was found to exist in a thin film of niobium pentoxide which had formed on niobium oxidized near 425°C in oxygen at atmospheric pressure for up to three hours. This compressive stress agreed very well with a known value of room-temperature compressive strength of niobium pentoxide of 117,000 psi. A compressive stress in an "effective" thin film of $NbO_x$ was found to be about 125, 150 or 177 thousand psi if the thin film is composed of $Nb_5O$, $Nb_2O$, or $Nb_4O$, respectively, the reported formulas for $NbO_x$. The resulting tensile stress on the substrate surface due to the oxidation process was found to be about 10,000 psi. It was found that the formation of niobium suboxide needles or plates, $NbO_x$, formed during the oxidation of niobium in the temperature range of 425 to 440°C, was a function of initial specimen oxygen concentration, oxidation temperature, and applied tensile stress. It was further found that when the oxygen concentration at the substrate surface had reached an equilibrium level and the suboxide plates had formed, only a small tensile stress (less than 10,000 psi on low oxygen content niobium) was needed to form microcracks in a surface of the metal associated with these suboxide needles. Evidence was given to show that these microcracks upon further oxidation formed niobium pentoxide wedges into the metal which caused premature failure of niobium metal parts. (Disser. Abstr.)

17207 CORROSION OF BASE-METAL ALLOYS IN AQUEOUS AND GASEOUS MEDIA. Berry, W. E. Reactor Mater.; 13: 44-6(Spring 1970).

A review is presented on the corrosion of base-metal alloys in aqueous and gaseous media. The corrosion of zirconium alloys was tested in air, steam, and water, and copper and nickel alloys in water. The corrosion of magnesium alloys was tested in carbon dioxide and the corrosive resistance of stainless steel was reported after testing in steam, water, and vacuum. (J.C.W.)

17208 CORROSION OF REFRACTORY METALS IN AQUEOUS AND GASEOUS MEDIA. Allen, B. C. Reactor Mater.; 13: 47-8(Spring 1970).

A review is presented on the corrosion of refractory metals in aqueous and gaseous media. The oxidation behavior of Nb–Ti in air, oxygen, and nitrogen at 650 to 1000°C and of Ta in $CO_2$ at 700 to 950°C are discussed. Tungsten alloys containing Nb and/or Ti are also mentioned. Additions of yttrium improved the oxidation resistance of chromium and resulted in tightly adhering oxide layers. Oxidation of rhenium research is reviewed. Corrosion of refractory metals in aqueous solutions included niobium and titanium alloys, such as Nb–Ta, and Nb–Ti. Improvements in silicide coatings for D-43 are also reported. (J.C.W.)

17209 CORROSION BY LIQUID METALS AND FUSED SALTS. Simons, E. M. (Battelle Memorial Inst., Columbus, Ohio). Reactor Mater.; 13: 49-58(Spring 1970).

A review is presented on corrosion in nuclear systems by liquid metals and fused salts. The compatibility of sodium with austenitic stainless steel, fast breeder reactor fuels, and ferritic steels is discussed along with corrosion in alkali metal and mercury Rankine cycle space power systems. Corrosion by lithium, lead–bismuth alloys, fused salts, and molten uranium alloys is also described. (J.C.W.)

17210 STEEL CORROSION IN MAGNOX REACTORS. Sutherland, D. M. (Nuclear Power Group Ltd., Knutsford, Eng.). Energ. Nucl. (Milan); 17: 95-7(Feb 1970).

An account is given of the problems arising in Magnox reactors, due to corrosion of mild steel occurring in certain parts of the gas circuit. Particular reference is made to the Bradwell and Latina reactors, and the work done at Latina to restore the plant in operation is described. (auth)

17211 THE BEHAVIOUR OF PALLADIUM AND ITS ALLOYS IN AIR AT HIGH TEMPERATURES. Tarasova, T. F.; Gil'dengorn, I. S.; Rogel'berg, I. L. Tr., Gos. Nauch.-Issled. Proekt. Inst. Splavov Obrab. Tsvet. Metal.; No. 29, 115-20(1969). (In Russian).

The scaling resistance of Pd and 45 binary Pd alloys was determined by measurement of weight changes over 24 hr, the alloy being held isothermally at 800, 1000, and 1200°C in air. The alloys contained ≤Fe 20, Ni 10, Co 10, Mn 10, Cr 17, Al 3, W 10, Mo 16, V 10, Re 10, Ir 18, Ru 5, or Ag 20%. At 1000 and 1200°C unalloyed Pd showed no change in weight, but at 800°C there was a weight gain of 0.03 mg/cm². As a rule the binary Pd alloys showed appreciable changes in weight due to internal oxidation of the alloying element, volatilization or fusion of its oxide, and evaporation of Pd. Alloys with Cr and Al were the most resistant. (Referationyi Zh.)

17212 STRUCTURAL CHARACTERIZATION OF CORROSION PRODUCTS BY INSTRUMENTAL METHODS. Vaughn, D. A. (Battelle Memorial Inst., Columbus, Ohio). pp 242-8 of Proceedings of the 25th Conference of the National Association of Corrosion Engineers. Houston, Tex.; National Association of Corrosion Engineers (1970).

From 25th Annual Conference of the National Association of Corrosion Engineers, Houston, Tex. See CONF-690304.

Methods and specific instrumentation in optical and electron microscopy that have increased the capabilities of analysts to characterize the morphology of corrosion products, to distinguish and separate phases, to observe unusual growth phenomena, and to correlate these physical characteristics with substrate or environmental factors are described. Instruments for chemical characterization are available for bulk and local analysis of nearly all elements in the periodic table. Through an analysis of the physical, chemical, and structural properties, corrosion products can be more completely identified and thus provide a better understanding of corrosion mechanisms leading to the degradation of materials. (J.C.W.)

17213 CORROSION OF COBALT AND COBALT ALLOYS: PRODUCTS AND MECHANISMS. Moral, F. R. (Battelle Memorial Inst., Columbus, Ohio). pp 260-75 of Proceedings of the 25th Conference of the National Association of Corrosion Engineers. Houston, Tex.; National Association of Corrosion Engineers (1970).

From 25th Annual Conference of the National Association of Corrosion Engineers, Houston, Tex. See CONF-690304.

The production and mechanism of corrosion products are reviewed. A literature survey is given for oxidation, sulfidation, and miscellaneous corrodents for the element cobalt and various binary, ternary, and quaternary cobalt-base alloys. Research has been directed towards the understanding of hot corrosion which is a combination of oxidation and sulfidation to which superalloys used in jet engines and gas turbines are subjected. (135 references) (J.C.W.)

17214 CORROSION AND HYDRIDING OF ZIRCALOYS UNDER HEAT TRANSFER CONDITIONS. Rubright, M. M.; Koch, D. W. (Babcock and Wilcox Co., Alliance, Ohio). pp 372-9 of Proceedings of the 25th Conference of the National Association of Corrosion Engineers. Houston, Tex.; National Association of Corrosion Engineers (1970).

From 25th Annual Conference of the National Association of Corrosion Engineers, Houston, Tex. See CONF-690304.

Zircaloy-2 and Zircaloy-4 specimens were evaluated for corrosion and hydrogen absorption characteristics. Three types of specimens involving exposure under heat transfer, dynamic isothermal, and static isothermal conditions were tested. Two types of pre-test surface conditions were used. One, the end-of-life, simulated the projected condition of cladding at the end of 1000 days of reactor operation. The other designated prefilm, had a surface coating equivalent to 15 to 25 mg/dm² formed by exposing the specimens to 750°F, 1500 psig high purity steam for 72 hr in an autoclave. Tables are presented for corrosion data for heat transfer and isothermal specimens. Hydrogen absorption data for heat transfer and isothermal specimens are also tabulated. A larger amount of available hydrogen is absorbed under heat transfer conditions than under isothermal conditions. Explanations of these test results are given. (J.C.W.)

17215 CORROSION BEHAVIOR OF NICKEL–CHROMIUM–IRON ALLOY 600 IN BORATED PRESSURIZED WATER REACTOR ENVIRONMENTS. van Rooyen, D. (International Nickel Co., Inc. Suffern, N. Y.); Copson, H. R.; Berry, W. E. pp 380-4 of Proceedings of the 25th Conference of the National Association of Corrosion Engineers. Houston, Tex.; National Association of Corrosion Engineers (1970).

From 25th Annual Conference of the National Association of Corrosion Engineers, Houston, Tex. See CONF-690304.

In borated water at 600°F the corrosion rate of alloy 600 decreased with time, and after 5000 hours the corrosion and oxide-released-to-stream rates were low, less than 1 mg/dm²/month. The influence of surface preparation and heat treatment was noticeable only during the first 1000 to 2000 hours of test, with grit

blasted or ground specimens exhibiting higher initial rates of attack (22 to 35 mg/dm²-month) than annealed specimens (11 to 14 mg/dm²-month). The reasons for the somewhat adverse effects of grit blasting or grinding have not been determined. Exploratory analyses indicated that the observed effects were not the result of gross changes in alloy chemistry at the specimen surface, at least within the precision of measurement of a depth of about one micron. Under the test conditions, the higher chromium content of weld 82 (19.7% chromium), and possibly an enriched chromium content at the surface from ferrochrome grit blasting, resulted in somewhat improved behavior during the first 2000 hours. With the same chromium content and a ground surface, wrought metal and weld metal behaved alike. Comparison of the data with earlier results in borate free water seemed to indicate that the addition of boric acid increased the corrosion somewhat during the first 2000 hours, but differences in test temperature and pH contributed to this. By 5000 hours the corrosion rates were low for all water chemistries and conditions investigated, and the presence of boric acid had no adverse effect on these low rates. The selection of materials for pressurized water reactors is influenced by many factors, among which are weldability and resistance to stress corrosion cracking. However, since alloy 600 has already been qualified for nuclear reactors, the tests were confined to weight loss measurements. These were expected to provide an indication of any unusual problems with activity build-up in borated water environments. The 5000 hour test data obtained showed lower long-time corrosion rates than previously reported. (auth)

**17216** SINGLE-PASS THROUGH-REACTOR DECONTAMINATION OF N REACTOR CARBON STEEL PIPING. Kratzer, W. K. (Douglas United Nuclear, Inc., Richland, Wash.). pp 414-24 of Proceedings of the 25th Conference of the National Association of Corrosion Engineers. Houston, Tex.; National Association of Corrosion Engineers (1970).

From 25th Annual Conference of the National Association of Corrosion Engineers, Houston, Tex. See CONF-690304.

The development of the decontamination procedure for the N Reactor is described. Using a proprietary inhibited phosphoric acid, Turco Decon 4512-A, the reactor was decontaminated in 1967 and 1968. Shortcomings of the procedure, e.g., localized pitting of carbon steel welded to stainless steel and redeposition of radionuclides in the downstream portion of the piping, were identified. This was the first through-reactor primary system decontamination of a large power reactor in the USA. (J.C.W.)

**17217** DECONTAMINATION OF N-REACTOR STAINLESS STEEL STEAM GENERATORS. Bainard, W. D. (Douglas United Nuclear, Inc., Richland, Wash.). pp 425-7 of Proceedings of the 25th Conference of the National Association of Corrosion Engineers. Houston, Tex.; National Association of Corrosion Engineers (1970).

From 25th Annual Conference of the National Association of Corrosion Engineers, Houston, Tex. See CONF-690304.

The process is described for the N-Reactor stainless steel tubed steam generator decontamination. Turco-4521 was used as the main decontaminant and the method and dilutions are given. Laboratory data indicated that temperatures are perhaps the most critical parameters. Because of the carbon steel piping in the N-Reactor cooling system, the corrosion film on the steam generator surfaces may be different from that found in an all-stainless-steel reactor system, but limited laboratory tests have not revealed any appreciable difference in difficulty of removal by the process. In applying this process to complex systems it is important to maximize the control over the solutions. Wherever possible the piping should be simplified by cutting and capping unused lines. Valving should not be relied upon unless unavoidable. Complete rinsing of solutions is important, not only for corrosion reasons, but for the effectiveness of the next step in the procedure. (J.C.W.)

**17218** MEASURING METHODS IN CORROSION PROTECTION. VOLUME 2. Conference, Prague, October 1–4, 1968. Prague; Czechoslovak Scientific and Technical Society (1968). 175p. (In several languages). (CONF-681077-(Vol.2)).

Twelve papers are included on the inhibition of corrosion processes in acid media. A separate abstract was prepared for one. The remaining 11 papers deal with corrosion information on materials not in scope for NSA. (J.C.W.)

*For an abstract of one paper see: 17219.*

**17219** THE METHOD OF STUDYING THE INHIBITION OF CORROSION PROCESS IN ACID MEDIA. Poutilova, I. N.; Souponitska, I. I.; Maslova, G. M. 11p. of Measuring Methods in Corrosion Protection. Vol. 2. Prague; Czechoslovak Scientific and Technical Society (1968).

From 42nd Conference of the European Federation of Corrosion, Prague, Czechoslovakia; See CONF-681077-(Vol.2).

Corrosion processes for iron in contact with hydrochloric acid and molybdenum in contact with nitric acid in the presence of different inhibitors were studied by microphotographic methods. Data characterizing the bubble formations are tabulated. The distribution of the number of hydrogen bubbles on the Fe-surface according to diameter and rate of increase is presented graphically. The distribution of the number of NO bubbles on the Mo-surface according to diameter is also presented in graphic form. (J.C.W.)

**17220** MEASURING METHODS IN CORROSION PROTECTION. VOLUME 3. Conference, Prague, October 1–4, 1968. Prague; Czechoslovak Scientific and Technical Society (1968). 210p. (In several languages). (CONF-681077-(Vol.3)).

Fifteen papers are included; separate abstracts were prepared for 2. The remaining papers deal with corrosion protection on materials not in scope for NSA. (J.C.W.)

*For abstracts of individual papers see: 17221 and 17405.*

**17221** EXPERIMENTS ON ARTIFICIAL CORROSION OF ELECTROLYTIC COATINGS OF ZINC AND CADMIUM. Talbot, J.; Cabrillac, M.; Morisset, M. 25p. of Measuring Methods in Corrosion Protection. Vol. 3. Prague; Czechoslovak Scientific and Technical Society (1968). (In French).

From 42nd Conference of the European Federation of Corrosion, Prague, Czechoslovakia. See CONF-681077-(Vol.3).

Studies were made of the corrosion of electrolytic coatings of cadmium and zinc on mild steel. (J.C.W.)

## Preparation and Fabrication

*Refer also to abstracts 16640, 16653, 16741, 16804, 17345, and 18036.*

**17222** (ARH-1198) PYROCHEMICAL PROCESS FOR THE REDUCTION OF PLUTONIUM DIOXIDE TO METAL. Felt, R. E. (Atlantic Richfield Hanford Co., Richland, Wash.). Jul 1969. Contract AT(45-1)-2130. 19p. Dep. CFSTI.

A pyrochemical process was developed for reducing plutonium dioxide directly to metal with calcium and a salt flux. Direct oxide reduction eliminates several intermediate processing steps, which generate waste streams requiring further processing. Waste recovery is nearly eliminated by this method of producing plutonium metal. The process was demonstrated by producing 2,000 grams of plutonium metal. Further equipment development is required to make the process operational. (auth)

**17223** (CEA-R-3905) α-GRAIN REFINING AND METALLURGICAL STUDY OF ALLOYED URANIUM, SICRAL F1, USED FOR FUEL ELEMENTS. Magnier, Pierre (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Nov 1969. 95p. (In French). Dep. CFSTI (U.S. Sales Only).

A study was made of grain refining in low alloyed uranium of composition similar to SICRAL F 1. Alpha grain refining of fuel elements made of these alloys was studied after casting and quenching by the methods used for mass production. Descriptions are given of the metallurgical history before quenching including casting, purity, and rate of solidification. Quenching parameters described include annealing temperature before quenching, annealing time, and quenching rate. The composition of the alloy is tabulated. For the graphite fuel elements of various dimensions, modifications are suggested to give a better adaptation of fabrication to size. The grain refining made during quenching and the $\beta \rightarrow \alpha$ and $\gamma \rightarrow \alpha$ transformation types is described. The use of a U–Fe–Si especially useful from the point of view of grain refining is proposed. (auth)

**17224** (CONF-681219-3) ACTIVITIES AND INNERSTRUCTURE OF CNEN FOR THE REUSE OF PLUTONIUM. Schileo, G. (Comitato Nazionale per l'Energia Nucleare, Rome (Italy)). [1968]. 26p. (In Italian). Dep. CFSTI (U. S. Sales Only).

From 10th International Nuclear Energy Conference, Milan, Italy.

The activities of the CNEN on the use of Pu are involved with the entire secondary fuel cycle from the chemical processing to the refabrication of plutonium nuclear fuels. The technology being developed includes making of tablets and the preparation and compaction of dense powders. The irradiations currently under study will serve as the basis of the use of Pu fuels in both thermal and fast reactors. The infrastructure of the CNEN is adequate for these research purposes so that at the proper time sufficient laboratory and pilot plant studies will be available to apply the data to the industrial processing and fabrication of these fuels. (J.S.R.)

**17225** (EUR-4398) COATING OF FISSILE PARTICLES BY HF INDUCTIVE PLASMA SPUTTERING. Beucherie, P.; Block, M. (European Atomic Energy Community, Ispra (Italy). Joint Nùclear Research Center). 18 Jul 1969. 10p. (In French). Dep. CFSTI (U. S. Sales Only). EUR.

High frequency inductive plasma sputtering is shown to constitute an interesting new method for coating loosely packed pieces of small dimensions, such as small spherical particles of fissile material with diameters of the order of 1 mm as used in certain types of nuclear reactors. A description is given of the experimental rig and the working conditions used for obtaining uniform surface coatings of such particles. (auth)

**17226** (KFK-1111) CARBIDE TYPE FUEL FOR FAST BREEDER REACTORS. Kummerer, K.; Thuemmler, F. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Material- und Festkoerperforschung). Oct 1969. 399p. (In German). (EUR-4315). Dep. CFSTI (U. S. Sales Only).

In the first half-year of 1969 a seminar on carbide-type fuels for fast breeder reactors was held in the Nuclear Research Center Karlsruhe, to serve as an introduction to this large field of applied fuel science. The object of this seminar was to gain a most comprehensive view of the present knowledge and experience on these fuels. Seventeen contributions to the seminar are compiled in an elaborated and supplemented form. They are self-contained. The most essential results of the discussions are added to every single report. Beginning with the significance of these fuels for the application in fast breeders and the corresponding points of view in terms of reactor physics and economics, the series of subjects cover the important physical and chemical properties, the irradiation behavior, and the fabrication and reprocessing methods within the fuel cycle. A conclusive evaluation of the present status of knowledge is made. In this context, the most important goals of future practical development are also characterized. (auth)

**17227** (ORNL-4480, pp 96-104) FABRICATION DEVELOPMENT FOR LMFBR STAINLESS STEEL TUBING. (Oak Ridge National Lab., Tenn.).

From Fuels and Materials Development Program Quarterly Progress Report.

Nine extrusion billets of Type 316 stainless steel were extruded into 2.1-in.-OD × 1.36-in.-ID × 50-in.-long tube shells. Two of the nine tube shells were tubes reduced to 1-in.-OD × 0.8-in.-ID × 240-in.-long tube hollows. Defects on the tube hollows were traced to a misaligned tail stock. The misalignment appears to have been a consequence of the methods used to instrument the tube reducer. Improved methods are being developed. Tubing was fabricated from Type 316 stainless steel (Allegheny-Ludlum Steel Corporation heat 65808) with variable reduction of area per pass and interpass annealing temperatures. Specimens from this lot of tubing are being prepared for tests of mechanical properties at 450, 550, and 650°C. Studies of planetary swaging are under way on Type 316 stainless steel. The swaging conditions caused unwanted surface flaking that became worse as the reduction per pass was increased. Concurrent work on Type 304 stainless steel indicates some of the reasons for the surface cracking. A tube that was ironed and sunk by planetary swaging developed surface cracks during the second pass, at 26% total reduction, while a tube that was sunk by mandrel drawing and ironed by planetary swaging had no defects after six passes (47% total reduction). Biaxial stress-rupture tests on planetary-swaged and mandrel-drawn tubing are in progress. (auth)

**17228** (ORNL-4480, pp 105-10) WELDING DEVELOPMENT FOR LMFBR VESSELS AND COMPONENTS. (Oak Ridge National Lab., Tenn.).

From Fuels and Materials Development Program Quarterly Progress Report.

Stress-rupture data on strength and ductility of stainless steel welds were used as the basis for a program to determine reasons for the large scatter in data—particularly in ductility. Base plate and filler wire were procured, and preliminary welds were made that bracket the range of practical welding conditions for the submerged-arc process. Specimens for preliminary tests of mechanical properties were prepared. Characterization of welds produced for the Fast Flux Test Facility weldment irradiation program is continuing. The electron microprobe is being used to determine the approximate composition of ferrite in the weld metal. (auth)

**17229** (ORNL-4480, pp 111-13) SHIELDED METAL-ARC WELDING FOR LMFBR COMPONENTS. (Oak Ridge National Lab., Tenn.).

From Fuels and Materials Development Program Quarterly Progress Report.

A series of electrodes were procured with Type 308 stainless steel coatings that have carefully controlled minor differences in composition. Welds were made in this material under carefully controlled conditions and samples were machined from them for irradiation and mechanical testing. (auth)

**17230** (ORNL-4480, pp 157-66) PHYSICAL AND MECHANICAL METALLURGY OF REFRACTORY ALLOYS. (Oak Ridge National Lab., Tenn.).

From Fuels and Materials Development Program Quarterly Progress Report.

The strong age-hardening effect observed in Ta–50 wt % Hf at 850°C is attributed to the $\beta$ to $\alpha$ eutectoid transformation of a Hf-rich phase and the precipitation of a large volume of fine particles. A similar but smaller effect was observed in a Nb–58 wt % Zr alloy. X-ray studies have not confirmed the existence of a miscibility gap in the Nb–Hf system as reported in the literature. Oxygen and nitrogen impurities may affect the phase relationship. The creep strength of TZM was shown to be a function of the reciprocal subgrain size produced by the fabrication variables. Several methods for joining Pt tubes to Ta–10% W tubes are being investigated. Various degrees of success for producing leak-tight joints were attained. The physical properties of Ta between 80 and 400°K are reported. (auth)

**17231** (ORNL-4480, pp 167-87) TUNGSTEN METALLURGY. (Oak Ridge National Lab., Tenn.).

From Fuels and Materials Development Program Quarterly Progress Report.

The effect of starting structures and extrusion temperature on the structure of duplex extruded powder-metallurgy W tubing were determined. At extrusion temperatures of 1450°C and higher, recrystallization and grain growth occur during preheat; but at 1150°C, a wrought extruded structure is produced if the material is recrystallized before extrusion. Methods for minimizing formation of nodules during the chemical vapor deposition of W–5% Re are being studied. Experiments with pulsing, reversing, and filtering the gas flow or increasing the $H_2$: ($WF_6$ + $ReF_6$) gas ratio were unsuccessful in eliminating the formation of nodules. In a feasibility study on chemical vapor deposition of V, dense metal deposits were obtained by the $H_2$ reduction of $VCl_4$ and $VF_5$ at temperatures above 900°C. A comparison of the creep-rupture properties of arc-melted and powder-metallurgy W–25% Re sheet at 1650 and 2200°C showed that the powder-metallurgy material has a shorter rupture life and lower rupture ductility than arc-melted material. On the basis of secondary creep rate, powder-metallurgy material is weaker than arc-melted material at 1650 but stronger at 2200°C. This behavior is explained by difference in grain-boundary mobility and void growth. Evaluation of the long-time creep and stress-rupture properties of arc-melted W–Re alloys was continued. Creep data at 1650°C and stress-rupture data between 1400 and 2200°C are presented for W–25% Re. Interrupted creep tests are also in progress on powder-metallurgy W at 1600°C along with examination of void distributions and dislocation configurations at strains between 2 and 10%. Studies on the effect of low pressure $O_2$ on the creep properties of W show the creep rate in $7 \times 10^{-5}$ torr $O_2$ is twice that at a base pressure of $1.3 \times 10^{-7}$ torr. This behavior is attributed to the higher rate of W sublimation in low pressure $O_2$ and to either O dissolving in the W or $O_2$ increasing the rate at which creep cavities grow. Joining studies on W alloy have revealed that filler metals having melting points lower than that of W minimize thermal stresses, recrystallization, and grain growth in the heat-affected zone. Powder metallurgy W sheet was successfully welded with Mo–Re and W–Mo–Re alloy filler metals. (auth)

**17232** (ORNL-4480, pp 256-65) JOINING RESEARCH ON NUCLEAR MATERIALS. (Oak Ridge National Lab., Tenn.).

From Fuels and Materials Development Program Quarterly Progress Report.

Inconel 600 hot-ductility specimens were metallographically examined to determine the effects of S, P, and Mn on their microstructures. The addition of nominal amounts of C, Mn, Si, and Cu to the ternary Ni–15.5% Cr–8% alloy resulted in a grain refinement in both the unaffected base metal and the fracture area of the hot-ductility specimens. At the zero-ductility temperature (ZDT), small amounts of S resulted in liquation in the grain boundaries and, as the level of S increased, in liquation in laminations in the base metal. Phosphorus had essentially no effect on the microstructure of the annealed base metal and no apparent effect on the microstructure of the area heated to the ZDT. Additions of Mn to an alloy nominally containing 0.010% S resulted in a coarsening of the grains. A mathematical model developed by Rensselaer Polytechnic Institute provides an acceptable statistical fit with the experimental data previously obtained on the effect of minor elements on the weldability of Inconel 600. Shielded metal-arc stainless steel welding electrodes for depositing 0, 2, 5, 7, 10, and 15% ferrite were obtained, and welds were made with an auto-

matic head. Bead-on-plate welds were produced at heat inputs from 10,000 to 60,000 J/in. These welds are being evaluated metallographically. Specimens containing documented discontinuities for short-time stress-rupture and tensile tests were produced. Scanning electron microscopy is being used to characterize weld fractures in Inconel 600. These will be compared to fractures in other Ni-base weld metals. (auth)

**17233** (SC-T-70-4008) CONCERNING A NEW, COMPLETELY NON-CRUCIBLE MELTING PROCEDURE (STIPPLING METHOD). Nickl, Julius J. Translated by Marcel I. Weinreich (Sandia Labs., Albuquerque, N. Mex.), from Z. Metallk.; 60: 800-2(1969). 7p. Dep. CFSTI.

A stippling method is described for use in melting granular and sponge-like raw materials without resorting to crucibles. The method can be used to produce polycrystalline or monocrystalline rods, which can be purified further according to well-known zone melting procedures, without using crucibles. Moreover, the stippling method makes it possible to manufacture tubes of high density. The advantage compared with suspension melting is the direct preparation of shaped objects from formless initial material. (auth)

**17234** SOME ASPECTS OF THE METALLOGRAPHY OF INDIUM AND ITS ALLOYS. Dasarathy, Cuppam (British Steel Corp., Port Talbot, Eng.). Prakt. Metallog.; 7: 44-6(Jan 1970). (In German and English).

Preparation of specimens of In for metallographic examination is described. Hand polishing using commercial polishing cloths and liquid polishing using commercial products followed by alcohol cleaning and etching was found successful. Methods are also described for preparation of In-base–Fe–Co alloys for metallography. (J.R.D.)

**17235** ZrHf NEWSLETTER, JANUARY 1970. Akron, N. Y.; AMAX Specialty Metals, Inc. 1970. 18p.

A review of development work on Hf and Hf alloys is presented along with information on Zr development, radiation effects on Zr alloys, and Zr effects as an alloying element with Ti, Mg, and Al. Technology concerning the production of Zr and Hf is reviewed along with properties of oxides, carbides, nitrides, and borides of these metals. 227 references are included. (J.R.D.)

**17236** FUEL CYCLE. Nucl. News; 13: 38-42(Jan 1970).

The production, conversion capacity, and enrichment of U are discussed. The enrichment plants in the U. S. will remain a government monopoly for the present. A complete industry capability exists to produce all types of fuel elements that have been used or are being considered. Enriched U was sent to foreign countries in the form of $UF_6$, but it is expected that soon all enriched U will be fabricated abroad. Utilities are expected to plan the recycle, sale, or storage of their plutonium. The utility actions transacted during 1969 were discussed concerning spent fuel reprocessing. Development of waste handling and management undertaken by nuclear companies is also discussed. (J.C.W.)

**17237** PREPARATION AND PROPERTIES OF SPUTTERED HAFNIUM AND ANODIC $HfO_2$ FILMS. Thomas, M. T. (Bell Telephone Labs., Inc., Murray Hill, N. J.). J. Electrochem. Soc.; 117: 396-403(Mar 1970).

Hafnium films sputtered at high voltages (4 kV) had a density of 98% of the bulk, specific resistivities as low as 50 $\mu$ohm-cm and temperature coefficient of resistance (TCR) as high as 1580 ppM/°C. Films with a density of 50% of that of the bulk, a specific resistivity of 815 $\mu$ohm-cm, and TCR of 800 ppM/°C were obtained at the lower sputtering voltages (1.5 kV). High- and low-density films had Hall coefficients of $-2 \times 10^{-5}$ cm$^3$/coulomb and $+12 \times 10^{-5}$ cm$^3$/coulomb, respectively. All the sputtered films had the same hexagonal close-packed structure as the bulk material, although the high- and low-density films had different preferred orientation. The oxide density, anodization constant, and dielectric constant for hafnium oxide were found to be 7.9 g/cm$^3$, 20 Å/V, and 18, respectively. The anodized hafnium oxide had a monoclinic polycrystalline structure with some preferred orientation, $(11\bar{1})$ or (001) plus $(10\bar{2})$. Test capacitors with anodic oxides formed to 100 V at 1 mA/cm$^2$ had capacitance density values of 0.085 $\mu$f/cm$^2$, dissipation factors below 0.01 at 1 kHz, and a frequency dependence of capacitance of ±1% in the range of 0.1 tc 100 kHz relative to the 1 kHz value. Temperature coefficient of capacitance values varied from 300 to 600 ppM/°C. (auth)

**17238** PRODUCTION OF NIOBIUM FILMS IN VERY HIGH VACUUM, THEIR HEAT TREATMENT AND ELECTRICAL PROPERTIES. Burmenko, K. I.; Ivanovskaya, G. F.; Orlov, A. F.; Osipov, K. A. Fiz. Khim. Obrab. Mater.; No. 5, 62-7(Sep-Oct 1969). (In Russian).

The production of Nb films (50 to 5000 Å) by vacuum deposition is described together with their subsequent heat treatment (at up to 1300°C, $10^{-6}$ torr) and electrical properties. The electrical resistance of the films falls and the temperature coefficient of electrical resistance rises after low-temperature annealing, due to the increased perfection of the crystal lattice. Films >1000-Å-thick annealed above 1000°C show an additional fall in resistance and a rise in the temperature coefficient of resistance due to recrystallization of the film material. (Metals Abstr.)

**17239** FACTORS CAUSING THE FAILURE OF POROUS TUNGSTEN DISCS ON WELDING TO COMPACT METALS. Ermishkin, V. A.; Fridman, Z. G. Fiz. Khim. Obrab. Mater.; No. 5, 105-9(Sep-Oct 1969). (In Russian).

Practical experience in the welding of porous W disks to compact metals is summarized and discussed, with special reference to the reasons underlying the failure of such joints in a large number of cases. The differences between the macroscopic physical properties of the two types of metal give rise to severe local stresses and the consequent generation and propagation of cracks. An approximate calculation of the stresses arising in a particular case is presented. Some practical recommendations are made in order to improve the conditions of welding under these circumstances. (Metals Abstr.)

**17240** POSSIBILITY OF ELECTROCHEMICALLY MACHINING NIOBIUM ALLOY PARTS. Egorova, O. I.; Ivanov, A. P.; Poluden, R. I.; Tolstaya, M. A. Fiz. Khim. Obrab. Mater.; No. 4, 145-9(Jul-Aug 1969). (In Russian).

The possibility of electrochemically machining Nb alloy parts in media of various ionic compositions (HCl, NaCl, NaOH, KOH, etc.) at various temperatures was studied. This treatment was only feasible at very low current density and was thus only suitable for finishing surfaces already made to a fairly fine tolerance. The main feature affecting the efficiency of the electrochemical machining of Nb alloys was the current density associated with the oxidation of the Nb. The best conditions were obtained by using 24% KOH at 80°C. (Metals Abstr.)

**17241** WELDABILITY OF MATERIALS [ZIRCONIUM TO STEEL] FOR THE NUCLEAR POWER INDUSTRY. Zapletalek, Alois. Zvaranie; 18: 174-8(Jun 1969). (In Slovak).

Properties of Zr alloy C2M (Zr–1% Mo–0.5% Cu) which are affected by flash welding of C2M to CSN 17246 austenitic steel were studied together with the structures of the joints. Hard brittle joints could be produced using a Ti layer on the Zr and Ni on the steel. Electron beam, Ar-shielded electric arc, and impulse welding could be used. (Metals Abstr.)

**17242** ANALYSIS AND OPTIMIZATION OF THE DECARBONIZING PROCESS DURING THE PRODUCTION OF VERY PURE METALS, IN PARTICULAR OF NIOBIUM. Melchior, G. (Max Planck Institut fuer Metallforschung, Stuttgart). Vakuum-Tech.; 18: 1-7(Feb 1969). (In German).

After some considerations concerning the production of very pure materials, the effects of various parameters which play a part in the process are investigated (i.e., temperature, composition of residual gas, ultimate pressure, and diffusion-constant). In particular, control of the purification process, by means of partial pressure measurements of gas-metal reactions, so that losses of material due to evaporation become a minimum and the procedure as a function of time becomes an optimum, is discussed. This is demonstrated by the decarbonization of niobium in vacuo. It was found that decarbonization in the liquid state for concentrations of a few ppM (order of magnitude) leads to difficulties due to evaporation losses of niobium. The relations used in the discussion can be applied to any purification process where the foreign matter is being removed by evaporation. The result of the investigation is a linear differential equation allowing an optimum control of the process. By using this relation and the measured values of the CO-partial pressure, furthermore by using the values of the time integral and the first derivation of this quantity, the temperature of the material can continuously be so adjusted that the alteration of the concentration of carbon as a function of time is a maximum. (auth)

**17243** ELECTRO-EROSION ETCHING OF BISMUTH, TELLURIUM, AND ANTIMONY SINGLE CRYSTALS. Bagai, I. M. Elektron. Obrab. Mater.; No. 3, 18-21(May-Jun 1969). (In Russian).

The mechanism underlying electro-erosion etching is discussed on the basis of practical experience gained in the electric spark cutting of Bi, Te, and Sb single crystals. During the cutting process, specific regions are subjected to intensive electro-erosion, and after subsequent chemical etching to remove the damaged surface layers these appear under the microscope as banded depressions. This effect is known as electro-erosion

etching. Micrographs show that this form of etching may prove of practical value in revealing the grain boundaries of polycrystalline aggregates. (Metals Abstr.)

**17244** STRUCTURE AND PROPERTIES OF THICK CONDENSATES OF NICKEL, TITANIUM, TUNGSTEN, ALUMINUM OXIDES, AND ZIRCONIUM DIOXIDE IN VACUUM. Movchan, B. A.; Demchishin, A. V. Fiz. Metal. Metalloved.; 28: 653-60 (Oct 1969). (In Russian).

The crystal structure and physical properties of thick condensates of Ni, Ti, W, aluminum oxides, and zirconium dioxide deposited on a base exhibited varying temperature characteristics at 3 structural zones. Microhardness, strength, and ductility of the condensates determine the peculiarities of the structures. An observation was made concerning the causes of the differences of character of condensation during transition from the first structural zone to the second. (tr-auth) (TSS)

**17245** ON THE DRAFT STANDARDS OF JIS FOR THE STEEL FORGINGS FOR NUCLEAR USE. Hasegawa, Masayoshi (Waseda Univ., Tokyo). Chuko To Tanko; No. 187, 31-8(Sep 1969). (In Japanese).

In Japan, atomic power stations are being built one after another, and the demands for nuclear-use steels are growing, and the demand for their domestic production has increased. In this connection, the draft standards of JIS have been completed by a committee, composed of members from the Government offices, academic circles, users, fabricators, and makers. The draft standards are based on those of ASTM, and will be subject to alterations in the future. Draft standard for the forgings of vacuum treated and heat treated carbon steel, and low alloy steel for pressure vessels, and draft standard for the forgings of heat treated carbon steel and low alloy steel for pressure-vessel parts are reviewed. (NSA of Japan)

**17246** DISLOCATION RELAXATION IN MOLYBDENUM AND NIOBIUM MONOCRYSTALS. Polotskii, I. G.; Prokopenko, G. I.; Nikitova, G. A. (Inst. of Metal Physics, Kiev). Fiz. Metal. Metalloved.; 28: 755-7(Oct 1969). (In Russian).

Studies were made on the effects of impurities on the relaxation maximums and aging in deformed Mo and Nb monocrystals. Vacuum melting was used for determining the content of carbon and other impurity gases. It was found that in the initial state, after annealing in vacuum at 1100°C for 2 hours, the decrement of damping depends very little on the temperature and is identical for all specimens. (tr-auth) (TSS)

**17247** EFFECTS OF ANNEALING ON MOBILITY OF DISLOCATIONS IN MOLYBDENUM AND TUNGSTEN MONOCRYSTALS. Benieva, T. Ya.; Golub, T. V.; Skopin, V. S. (Inst. of Metal Physics, Kiev). Fiz. Metal. Metalloved.; 28: 700-4(Oct 1969). (In Russian).

The effects of annealing on amplitude damping in Mo and W monocrystals were studied and the tangent microintensities were determined. Tungsten was studied at 1900°C in vacuum and Mo was studied at 1100°C in vacuum. (tr-auth) (TSS)

**17248** TANTALUM METAL BY BOMB REDUCTION OF $Ta_2O_5$. Wilhelm, H. A.; Bergman, R. M.; Schmidt, F. A. (Ames Lab., Iowa). J. Metals; 22: 45-9(Jan 1970).

A practicable approach to the preparation of massive, high purity, ductile tantalum metal by a bomb reduction process was demonstrated in a laboratory scale operation. In the process, tantalum pentoxide is reduced with aluminum in the presence of alloying agents. Certain combinations of iron, silicon, manganese and aluminum are used as alloying elements to lower the solidification temperature of the metal phase and, therefore, facilitate the slag-metal separation. Tantalum metal yields in the reduction step were consistently in excess of 83%. Subsequent removal of the alloying elements and impurities was accomplished by heating the regulus in vacuum. The purified tantalum was ductile and typically contained <10 ppM oxygen, <10 ppM nitrogen, ~25 ppM carbon and <125 ppM of residual alloying elements. (auth)

**17249** CATHODIC ETCHING TO PREPARE METALS FOR OXYGEN DETERMINATION. Hill, John H.; Morris, C. J.; Frazer, Jack W. (Univ. of California, Livermore). Analyst; 95: 215-18(Feb 1970).

A cathodic etching method has been developed to clean the surfaces of metal samples prior to oxygen determinations. The sample becomes the cathode in a low-pressure argon-ion discharge. The argon ions bombard the surface of the sample and remove the oxide film by an etching process. The oxygen content of metal samples cleaned by cathodic etching is consistently lower than that of samples cleaned by filing. In addition, contamination from radioactive samples is minimized because the sputtered metal deposits on surfaces inside the etcher assembly. (auth) (UK)

**17250** SIMPLE CELL FOR THE ELECTRODEPOSITION OF TRACES OF METAL ON THIN METALLIZED PLASTIC FILMS. APPLICATIONS TO THE PREPARATION OF RADIOACTIVE SOURCES OF $^{60}Co$, $^{110m}Ag$, $^{203}Hg$, $^{63}Ni$, AND $^{65}Zn$. Ujihira, Y.; Roy, J. C. (Laval Univ., Quebec). Can. J. Chem.; 46: 1221-32 (15 Apr 1968).

A simple and rapid electrochemical technique for the preparation of uniform and adherent metal deposits on thin metallized plastic films has been developed. It is based on the use of an electrolytic cell, characterized by the separation of the anode and cathode compartments by a fritted glass disc. Furthermore, electrodeposition is achieved from a solution having a volume of only 0.15 ml. The technique and the conditions used to realize the electrodeposition on thin metallized plastic films are described. The cell has been used to electrodeposit many metals, mostly by spontaneous electrodeposition using a magnesium anode and also by application of an external voltage using a platinum anode. The experimental conditions and a report on the results dealing with the electrodeposition of Co, Ni, Ag, Hg, and Zn are described. Deposits of less than a microgram to several hundred micrograms per square centimeter were obtained with high yields in 10 to 40 min. The use of the technique for the preparation of radioactive sources of $^{60}Co$, $^{63}Ni$, $^{110m}Ag$, and $^{203}Hg$ for absolute rate determinations is reviewed. (auth) (Canada)

**17251** NEW TECHNIQUE FOR JOINING POROUS REFRACTORY METALS. Dewey, C. Forbes Jr. (Univ. of Colorado, Boulder). Contracts AT(11-1)-1776; AFSC F 33615-67-C-1850. AIAA (Amer. Inst. Aeronaut. Astronaut.) J.; 7: 1192-3(Jun 1969).

A technique used to join high-porosity Ta–W matrices to thin solid-Ta support structures is described. The porous material is machined to size then a thin coating of Ta is applied to the machined surface, using vapor deposition. A weld is then effected between the coating and the support structure. (J.R.D.)

**17252** SYNTHESIS AND FABRICATION OF (U,Pu)C NUCLEAR FUEL PELLETS FROM U–Pu ALLOY. Nelson, P. A.; Grosvenor, D. E.; Vogler, S.; Quattropani, N. P.; Krause, P. W. (Argonne National Lab., Ill.). Amer. Ceram. Soc. Bull.; 48: 863-6(Sep 1969).

The conversion of U–Pu alloy to a powdered (U,Pu)C solid solution and the subsequent pressing and sintering of the powdered product into fuel pellets is discussed in view of the potential production applications of techniques for preparing (U,Pu)C fast-reactor fuel from both metallic and oxide feed material. A fluidized-bed process was developed for producing (U,Pu)C powder from bulk U–Pu alloy. The carbon content of the product can be controlled at the mean stoichiometric monocarbide value of 4.80 wt %, and oxygen contamination can be controlled to less than 500 ppM. The powder produced is suitable for pressing and sintering into pellets without milling or the addition of binders or sintering aids. The 2100°C sintering temperature required to reach a density of 85 ± 3% of the theoretical value is much higher than the temperature normally required for sintering (U,Pu)C. Although uneven shrinkage during pellet sintering caused the pellets to be slightly distorted, removal of only 2 to 3% of the pellet weight by centerless grinding produced cylindrical pellets of reproducible dimensions. The high sintering temperature is not considered to be a disadvantage since it was demonstrated that the pellets could be sintered at this temperature without large Pu losses. Also, it is hoped that the high sintering temperature may yield pellets that are dimensionally stable at high irradiation temperatures. The process could be adapted easily to the semi-remote handling procedures that may be required with recycled Pu. A metallic feed material is required, however, and the utility of this process may depend on whether pyrochemical methods are used for reprocessing fast reactor fuels. (BBB)

**17253** WELDING SHIELD ARRANGEMENT. (to Centre d'Etude de l'Energie Nucleaire). British Patent 1,183,464. 4 Mar 1970. Priority date 18 Mar 1966, Luxemburg.

A shield arrangement is described for use during welding of elements which are reactive at high temperatures with air. The rig has an inlet section, a central welding section, and a venturi shaped outlet section. A welding electrode is mounted so that it projects into the welding section from the inlet section allowing inert gas to flow into the casing and around the electrode. Mounts are incorporated in the casing adjacent to the electrode so that a welding arc can be formed between the electrode and the welding work. (J.R.D.)

**17254** PREPARATION OF COLUMBIUM METAL BY CALCIUM HYDRIDE REDUCTION OF COLUMBIUM PENTOXIDE. Mukher-

jee, T. K.; Kamat, G. R.; Gupta, C. K. (Bhabha Atomic Research Centre, Bombay). J. Metals; 22: No. 2, 50-3(Feb 1970).

A process of Nb metal production through the reduction of its oxide with calcium hydride is described. Both vacuum sintering and electron beam melting of the hydride reduced Nb powder ultimately result in consolidated metal of comparable purity and ductility. (auth)

17255 MOLYBDENUM'S PLACE IN THE PRESSURE-VESSEL FIELD. Dunn, R. G.; Whiteley, G. F.; Fairhurst, W. Greenwich, Conn.; Climax Molybdenum Company ([1970]). 266p. Climax Molybdenum Company, New York.

Selection of materials for construction of various types of pressure vessels is discussed. The advantages of Mo as an alloying element are noted in areas such as increased material strength and increased toughness and resistance to embrittlement. Information is also included on forming, joining, heat treating, and hydrostatic testing of pressure vessels. (J.R.D.)

## Properties Evaluations

*Refer also to abstracts 16503, 16775, 16787, 16807, 17235, 18631, 18632, 18649, and 18668.*

17256 (BMI-1901) SURVEY OF LMFBR COMPONENT MATERIALS, LIMITATIONS AND REQUIREMENTS. Bauer, Arthur A.; Conner, Jack G. (Battelle Memorial Inst., Columbus, Ohio). Jan 1970. Contract W-7405-eng-92. 140p. Dep. CFSTI.

The materials needs for selected LMFBR components, operating with sodium coolants at temperatures up to 1200°F, the functions, general design, operating characteristics, history of materials selection, and materials problems and limitations for the coolant transport system, pumps, intermediate heat exchanger and steam generator, control-rod drive and fuel-handling mechanisms, and core components are reviewed. Major materials requirements identified are associated with the need for mechanical-property design data, the problems and materials limitations resulting from corrosion and mass transfer in sodium, the evaluation and selection of wear-resistant materials for guide, bearing, and seal applications, the development of techniques to weld reliable tube-to-tube sheet joints, and the irradiation-induced swelling and ductility loss of structural materials exposed to a fast-neutron-flux environment. (auth)

17257 (JUL-606-FN) DIFFUSION OF HYDROGEN AND DEUTERIUM IN NIOBIUM AND VANADIUM. Schaumann, Gunter (Kernforschungsanlage, Juelich (West Germany). Institut fuer Festkoerper- und Neutronenphysik). Jul 1969. 85p. (In German). Dep. CFSTI (U. S. Sales Only).

The diffusion constants of hydrogen and deuterium were determined in Nb and V. A method was developed with which the elastic diffusion secondary effect of rapidly moving point defects could be detected. Each point defect, which caused a lattice parameter change and was found in an inhomogeneous distortion field, gave rise to a relaxation process. In the case under investigation the hydrogen atoms diffused into Nb and V from the compressed into the dilated range of the lattice with a velocity determined by its diffusion constant, by which a time-dependent supplementary expansion—the diffusion secondary effect—is formed. For hydrogen in Nb and V the relaxation intensity of the diffusion secondary effect was calculated from literature data for the H-induced lattice expansion. Both in the lattice parameter change and in the relaxation intensity the trace of the double force tensor enters as a decisive magnitude. The calculated values for the relation intensities were satisfied experimentally. The time pattern of the measured secondary effect curve can be described in agreement with the theoretical calculations by a pure exponential function. The simple relaxation process found was with only a relaxation time from which the diffusion constants for hydrogen diffusion was determined. The absolute values of the diffusion constants are at room temperature about 15 to 25 orders of magnitude over the diffusion constants of O, N, and C in cubic body-centered metals. Both for Nb and V a large isotropic effect was found for the hydrogen diffusion which at 300°K is 2.3 for Nb and 3.1 for V. In both cases a higher temperature dependence of the diffusion coefficients was found for deuterium. The average jump of hydrogen in V at T = 300°C is comparable with the highest oscillation frequency of the lattice. With help of the energy difference ΔE between the ground state and the first excited state of the H atom in the metal lattice, determined from inelastic neutron scattering, the oscillation frequence of the H atom at its lattice site can be calculated in case it is maintained as an Einstein oscillator. It was shown why in the measured temperature range the assumption for application of the classical jump theory is no longer fulfilled for the diffusion. In the temperature range over 300°K an activation energy of U = 0.11 ev can be determined from the diffusion data for H in Nb, which agrees with the value ΔE for the hydrogen atom in Nb lattice determined from inelastic neutron scattering. On the basis of these data and the temperature dependence of the diffusion constants which is very weak at low temperatures, a quantum mechanical description of the results can be given in a band model. (tr-auth)

17258 (NYO-4073-1) STUDY OF MICROPLASTIC BEHAVIOR OF TUNGSTEN AND OTHER REFRACTORY METALS IN RELATION TO THE BRITTLE FRACTURE PROBLEM. Progress Report, April 1, 1969-December 31, 1969. Bilello, John C. (State Univ. of New York, Stony Brook. Coll. of Engineering). Contract AT(30-1)-4073. 16p. Dep. CFSTI.

A system for measuring microplasticity and strain-rate response of materials over a temperature range of 4.2 to 300°K has been designed and built. Preliminary measurements on polycrystalline tungsten indicated that three distinct regions of strain-rate behavior occurred in cases where a yield-point is observed. The temperature dependence of the "friction stress" in single crystal tungsten was found to be similar to that of the flow stress. Correlation of the dislocation structure with the measured low frequency mechanical hysteresis of the same Cu crystals showed that primary-forest junctions with binding energies of ~1 eV were the pinning agents controlling the damping behavior. (auth)

17259 (ORNL-4480, pp 152-6) CLADDING MATERIALS FOR SPACE ISOTOPIC HEAT SOURCES. (Oak Ridge National Lab., Tenn.).

From Fuels and Materials Development Program Quarterly Progress Report.

Studies of the interaction of stress and vacuum on the creep properties of Haynes alloy No. 25 were concluded. Degradation of creep strength due to the evaporation of volatile alloying elements was found to be most severe in thinner materials. This behavior is attributed to the greater volume fraction of the specimen that is affected, which reduces the amount of the strengthening Laves phase that can be precipitated. An ordered developmental alloy (Ni-38.8% Co-22.5% V) was shown to have a marked advantage in creep strength over conventional alloys, including Haynes alloy No. 25. Investigations are in progress on Pt-based alloys in an attempt to combine the advantages of higher melting point, negligible evaporative losses, superior oxidation resistance, and the strengthening provided by ordered structure. Studies are in progress on Pt-Cr and Pt-Mo alloys. (auth)

17260 (ORNL-4480, pp 274-96) IMPROVEMENT OF HASTELLOY N AND RELATED COMPOSITIONS. (Oak Ridge National Lab., Tenn.).

From Fuels and Materials Development Program Quarterly Progress Report.

Several chemical modifications of Hastelloy N are being studied in an effort to develop an alloy with improved resistance to embrittlement by neutron irradiation. Additions of 1% Ti result in an alloy containing the MC type of carbide with good properties both before and after irradiation. Lesser amounts of Ti lead to the formation of mixed MC and $M_2C$ types of carbides with less attractive properties. Alloys that contain Nb, Hf, and Y also look promising with fracture strains of 4 to 23% (compared with 0.5 to 3% for standard Hastelloy N). There still appears to be a strong correlation between good postirradiation properties and formation of the MC type of carbide. (auth)

17261 (WAPD-TM-900) HIGH-TEMPERATURE DEFORMATION AND BURST CHARACTERISTICS OF RECRYSTALLIZED ZIRCALOY-4 TUBING (LWBR DEVELOPMENT PROGRAM). Busby, C. C.; Marsh, K. B. (Bettis Atomic Power Lab., Pittsburgh, Pa.). Jan 1970. Contract AT(11-1)-Gen-14. 15p. Dep. CFSTI.

Internal pressure burst tests of unirradiated, recrystallized Zircaloy-4 tubing were performed at isothermal temperatures ranging from 80° to approximately 1900°F to assess deformation characteristics before fracture. It was concluded that significant local deformation (bulging) could occur. It is also shown that a reasonable estimate of flow stress under combined stress loading can be obtained from uniaxial tensile data and a strain parameter (R) measured from the contractile strains observed in tensile tests. (auth)

17262 EFFECT OF MEAN STRESS AND OF MEAN STRAIN IN LOW-CYCLE FATIGUE OF A-517 AND A-201 STEELS. Dubuc, J.; Vanasse, J. R.; Biron, A.; Bazergui, A. (Ecole Polytechnique, Montreal). J. Eng. Ind.; 92: No. 1, 35-52(Feb 1970).

A number of low-cycle fatigue tests has been carried out at room temperature on two materials commonly used in pressure vessel fabrication. For strain-controlled tests, the influence of different

mean strains is studied; similarly, the effect of varying the mean stress is analyzed for stress-controlled tests. Relations involving elastic and plastic strain ranges, and the variations of strains or stresses during the fatigue tests are discussed. (auth)

**17263** FRACTURE INITIATION IN LOW STRENGTH STEEL PRESSURE VESSELS. Cowan, A.; Kirby, N. (United Kingdom Atomic Energy Authority, Culcheth, Eng.). J. Eng. Ind.; 92: No. 1, 79-85(Feb 1970).

Tests to failure have been made on 5 ft dia × 1 in. thickness steel pressure vessels containing longitudinal slits through wall thickness representing natural defects. Steels of from 33,000 to 70,000 psi yield strength have been tested over a range of temperatures with defects of 6, 12 and 24 in. length. When the toughness exceeds 20/30 ft lb Charpy V-notch energy, failure occurs by plastic collapse, and failure conditions can be predicted from the tensile properties of the steel. At lower levels of toughness the concept of a constant crack opening displacement (COD) at fracture initiation of defects in pressure vessels and in notched bend specimens can be used to predict vessel failure conditions. Recognition must be made of the variables found in COD notched bend testing, and tests are necessary to determine the most embrittled area of a pressure vessel. Examples are given of the method of application of COD and the degree of embrittlement possible in a low alloy steel. (auth)

**17264** TEMPERATURE DEPENDENCE OF THE ELECTRICAL RESISTIVITY OF LIQUID METALS. Solov'ev, A. N. (Inst. of Thermophysics, Novosibirsk, USSR). Teplofiz. Vys. Temp.; 7: 177-8(1969). (In Russian).

Within a broad temperature range, the temperature dependence of the specific electrical resistivity of liquid metals deviates strongly from a linear correlation. For this reason it is difficult to calculate the mean free path $\tau$ of electrons in a liquid metal. If N is the number of scattering centers and $\sigma$ is the scattering cross section, then $\lambda = 1/N\sigma$. The mean amplitude of thermal oscillations of the ions which determines the scattering cross section is derived from the difference of atomic distances. The theoretical derivations were checked by examining the averaged data of several authors concerning the electrical resistivities. For sodium, the data were plotted from the melting point to 1700°K; the expected straight-line correlation was found. Similar agreement was found for Rb, Cs, Sn, Ag, Au and Ga. The results indicate that Fermi statistics may be applied and that at relatively high temperatures, the electrons become degenerate. Beyond about 1300°C, K, Rb and Cs deviate from the expected linear correlation. (TTT)

**17265** PLUTONIUM-DOKUMENTATION. Referate-Zeitschrift mit Anhang Transplutonium-Elemente. Januar 1970, Band 4, Heft 1. 157 Referate (Register-Nr. 1-313). (Plutonium-Documentation. Abstract Journal with Appendix on Transplutonium Elements. January 1970. Vol. 4, No. 1. 157 Abstracts (Register No. 1-313)). Karlsruhe, Ger.; Gesellschaft fuer Kernforschung m. b. H. (1970). 100p. (In German and English).

**17266** TUNGSTEN NEWS. MARCH 1970. Tungsten News; 1-18(1970).

The application of tungsten carbides in cutting tools, grinders, gages, instruments, and bearings is discussed. The use of tungsten metal in tungsten-halogen lamps, tail sections of aircraft, crucibles, tubing, nuclear fuel pins, and thermionic converters is reviewed. The increasing use of tungsten-base alloys in high-temperature thermocouples, machine tools, and for reactor shielding is summarized. Methods for sintering tungsten, producing thoriated tungsten, and joining tantalum to tungsten are described. The effects of tungsten as an alloying element are given. The recovery of tungsten from wolframite was studied and the analysis of tungsten metal and trioxide for molybdenum discussed. Applications of tungsten compounds, other than carbides, are given. 231 references. (R.C.K.)

**17267** EFFECT OF CARBON AND NICKEL ON THE ELASTIC MODULUS AND VARIOUS MECHANICAL PROPERTIES OF ELECTRON-BEAM-MELTED MOLYBDENUM OVER A WIDE TEMPERATURE RANGE. Voitenko, A. F.; Movchan, B. A.; Nadezhdin, G. N.; Pisarenko, G. S.; Statkevich, V. N. Fiz. Khim. Obrab. Mater.; No. 5, 88-94(Sep-Oct 1969). (In Russian).

The elastic moduli of pure electron-beam-melted Mo and certain Mo alloys containing Ni and C were studied at 77 to 1800°K, and the UTS, YS, and hardness determined at 300 to 1800°K. The formation of a second phase (from elements originally in solution with Mo) slightly reduced the elastic modulus at 25°C but greatly increased the ductility. A high 900 to 1000°C the elastic moduli for the two-phase alloys, in particular, had very high elastic moduli and UTS. (Metals Abstr.)

**17268** EFFECT OF CLEANING TECHNIQUE ON THE OUTGASSING RATE OF 18/9/1 STAINLESS STEEL. Barton, R. S.; Govier, R. P. (United Kingdom Atomic Energy Authority, Abingdon, Eng.). Vacuum; 20: 1-6(Jan 1970).

A series of experiments are described that are designed to assist in determining the extent to which the room temperature outgassing rate of stainless steel can be reduced by cleaning processes only without recourse to vacuum bakeout. The effect of contact with clean hands on the outgassing of a stainless steel vacuum surface is also discussed. (auth) (UK)

**17269** HIGH-TEMPERATURE THERMODYNAMIC PROPERTIES OF SOLID REFRACTORY METAL ALLOYS: THE TANTALUM–MOLYBDENUM, TANTALUM–TUNGSTEN AND NIOBIUM–MOLYBDENUM BINARY SYSTEMS. Singhal, Subhash Chandra. Philadelphia; Univ. of Pennsylvania (1969). 134p.

Thesis.

The thermodynamic properties of the solid Ta–Mo, Ta–W and Nb–Mo alloys have been determined between 1000 and 1300°K by employing solid state galvanic cells with $ThO_2$–$Y_2O_3$ electrolytes. These alloy systems exhibit negative deviations from Raoult's law. The negative deviation from ideality is greatest for the Ta–Mo system and decreases from Nb–Mo to Ta–W system. It is believed that a charge transfer occurs on alloying causing the large negative deviation from ideality. The excess entropies of mixing in these alloy systems are very small and negative, and the excess free energies of mixing are largely due to the heats of mixing contribution. The excess entropies of mixing have been interpreted in terms of possible long or short range ordering in these alloy systems, but no definite x-ray evidence has been obtained. (Disser. Abstr.)

**17270** EFFECT OF SOME ELEMENTS ON SULPHUR ACTIVITY [IN IRON]. Buzek, Zdenek; Chmelar, Ivan; Schindlerova, Vera. Hutn. Listy; 24: 498-509(Jul 1969). (In Czech).

The effect of Zr, Hf, Ti, Mn, U, Al, C, Si, and B at 1600°C, and of Ni, W, Co, Mo, and Nb at 1635°C, on the activity of S in Fe was studied. Al, Si, B, and C increase and Mn, U, Hf, Ti, and Zr reduce the coefficient of S activity. Similarly W and Mo increase and Co, Ni, and Nb reduce the coefficient. The dependence of interaction coefficient on the number of free effective electrons was applied to the theoretical determination of the negative effect of Sc, Y, and La which in this sequence, reduce the coefficient. (Metals Abstr.)

**17271** THERMO-EMF OF BINARY PALLADIUM-BASE SOLID SOLUTIONS. Tarasova, T. F.; Rogel'berg, I. L.; Gil'dengorn, I. S. Tr., Gos. Nauch.-Issled. Proekt. Inst. Splavov Obrab. Tsvet. Metal.; No. 29, 5-23(1969). (In Russian).

Measurements were made of the thermo-emf of Pd and 52 binary Pd-base alloys. These alloys contained Al, Co, Cr, Fe, Mn, Mo, Nb, Ni, Re, V, W, Ir, and Ru within the solid solution limits. The data are compared with other published results in tables and graphs. The majority of the elements increase the thermo-emf of Pd and only additions of Ag, Au, Cu, Al, and Mn decrease it. The effect of Al, Co, Cr, Fe, Mn, V, Mo, Nb, Re, and W on the thermo-emf of Pd is analogous to the effect of these elements on the thermo-emf of Ni. (Referativnyi Zh.)

**17272** INFLUENCE OF WELD METAL COMPOSITION ON FORMATION OF COLD CRACKS WHEN WELDING MEDIUM ALLOY STEELS. Baryshnikov, A. P. Avtomat. Svarka; No. 7, 1-4(Jul 1969). (In Russian).

The test materials were medium-alloy steels with a C equivalent of 0.89 to 0.92%. The specimens were semi-automatically $CO_2$ welded with electrodes with a C equivalent of 0.38 to 0.75. The composition of the low-alloy weld metal can influence the formation of cracks in multi-run $CO_2$ welding. The possibility of crack formation increases with increased alloying. An increase of the Mn content by more than 1.4% in the low-alloy Cr–Ni–Mo–Mn electrode intended for $CO_2$-welding of medium-alloy steels is undesirable from the point of view of eliminating cold cracks. (Metals Abstr.)

**17273** THERMAL CONDUCTIVITY OF HOLMIUM BELOW 1°K. Anderson, A. C.; Malinowski, M. E. (Univ. of Illinois, Urbana). Phys. Status Solidi; 37: K141-3(1 Feb 1970).

The thermal conductivity of 99.9% pure Ho was measured at 0.05 to 1.0°K. The plot of thermal conductivity vs temperature is a straight line and gives $\kappa = (3.02 \pm 0.03)T$[mW/cm deg]. The Lorenz ratio is $2.53 \times 10^{-8}$ W$\Omega$/deg$^2$; $L/L_0 = 1.03$. No anomaly was observed. (D.L.C.)

**17274** REACTOR MATERIALS. VOLUME 13, NUMBER 1. Simons, E. M.; Keller, D. L. (eds.). One of Four Technical Progress Reviews Published for the Division of Technical Information, USAEC. Columbus, Ohio; Battelle Memorial Inst. (Spring 1970). 64p. GPO $0.70.

Ten sections are included; separate abstracts were prepared for 9. The remaining paper very briefly discusses cladding behavior in loss-of-coolant accidents. (J.C.W.)

*For abstracts of individual sections see: 17207–17209, 17275–17277, 17333, 17366, and 17401.*

**17275** METALLURGY OF COMMON CLADDING MATERIALS. Kangilaski, M. Reactor Mater.; 13: 1-13(Spring 1970).

A review is given on the properties of common cladding materials for reactor fuels. Recent research on Al, Mg, Ni, and Zr alloys, stainless steels, ferritic steels, and zirconium is summarized. (51 references). (J.C.W.)

**17276** METALLURGY OF REFRACTORY METALS. Peterson, J. H. Reactor Mater.; 13: 14-17(Spring 1970).

A review is presented on the metallurgical properties, such as tensile strength, ductile-brittle transition temperatures, and creep, for W and Re metal and alloys, Nb and Ta alloys, and Cr. (J.C.W.)

**17277** DIFFUSION STUDIES. Ashurst, A. N. Reactor Mater.; 13: 18-20(Spring 1970).

A brief review is presented on solid-state diffusion in refractory metals, stainless steel, and aluminum and diffusion of gases in solids. Data are tabulated on interdiffusion in refractory metal couples and diffusion equations are given. (J.C.W.)

**17278** THERMODYNAMICS OF VAPORIZATION OF CERIUM. Ackermann, R. J.; Kojima, M.; Rauh, E. G.; Walters, R. R. (Argonne National Lab., Ill.). J. Chem. Thermodyn.; 1: 527-33 (Nov 1969).

Neutron activation analysis of the vapor was used to redetermine the vapor pressure of liquid Ce. Results of previous studies are not consistent with the thermodynamic properties of gaseous and liquid Ce. Both mass effusion and mass spectrometric measurements were combined to yield the vapor pressure equation: $\log_{10}\{p(Ce)/atm\} = 5.500 \pm 0.029 - (21\,070 \pm 55)K/T$, (1525 to 2225°K). Mass spectrometric observations also demonstrated that oxygen contamination, which vaporizes as CeO(g), could be reduced to an insignificant level only after ~20% of the sample was evaporated. The enthalpy of vaporization of Ce and its standard deviation at 2000°K evaluated from the temperature dependence of the vapor pressure is (96 420 ± 250) cal $mol^{-1}$, and the value determined from the measured values of the vapor pressure combined with the free energy functions of liquid and gaseous Ce is (96 125 ± 50) cal $mol^{-1}$. The enthalpy of sublimation calculated at 0°K is (99 350 ± 500) cal $mol^{-1}$. The measured value of the entropy of vaporization and its standard deviation at 2000°K is (25.17 ± 0.13) cal $K^{-1}$ $mol^{-1}$ compared with the value (25.00 ± 0.15) cal $K^{-1}$ $mol^{-1}$ calculated from absolute entropies. (BBB)

**17279** LINEAR ELASTIC FRACTURE MECHANICS: A REVIEW OF PRINCIPLES AND METHODS. Srawley, J. E. (Lewis Research Center, Cleveland). pp A1-13 of Practical Fracture Mechanics for Structural Steel. /Dobson, M. O. (ed.). London; Chapman and Hall, Ltd. (1969).

From Symposium on Fracture Toughness Concepts for Weldable Structural Steel, Risley, England. See CONF-690440.

Linear elastic fracture mechanics is the simplest form of fracture mechanics which has much practical utility. It makes use of a macroscopic model in which attention is focused on the "worst flaw" that is known, or assumed, to occur in a structural member, and which is idealized as a sharp crack in a linear elastic continuum. The existence of a small plastic enclave around the crack front is recognized, and the core of this plastic enclave is the site of crack extension processes induced by steady or varying loads carried by the member. In order to relate behavior in one situation to that in another (for example, a laboratory test result to behavior of a structural member in service), use is made of the singular stress field equations for an ideal elastic crack. The crack extension process is assumed to be controlled primarily by one of three scalar stress field parameters, the mode I stress intensity factor $K_I$, and by the effective degree of plane strain. In effect, the remote boundary conditions on the plastic enclave are replaced by local boundary conditions given by the singular elastic crack tip stress field. The appropriate results from theory of elasticity are available for many two-dimensional cases and for buried elliptical cracks. The theory is most successful for problems which can be treated as two dimensional plane strain. The alternative simple cases of plane stress and anti-plane shear (or mode III), while of considerable didactic value, have little practical application. It is common, however, to refer to some complex situations which are really neither plane stress nor plane strain as plane stress. In such cases behavior depends quite strongly on the thickness of the structural member. Practical application of the theory is limited to situations of "small scale yielding," which means that specimen and crack dimensions have to be several times as large as the plastic enclave size factor, defined as the square of the ratio of stress intensity factor to yield strength. In spite of this limitation there are many successful applications, particularly for high strength materials, to fracture, fatigue crack propagation, and to stress corrosion cracking problems. An ASTM Proposed Test Method for Plane Strain Fracture Toughness has been developed, so that determination of values of this basic property can be standardized. Considerable theoretical and experimental work is in progress to develop a more comprehensive (and necessarily more complex) fracture mechanics. The existing basis of linear elastic theory is invaluable in this endeavor. There are also many essentially empirical expedients available which permit practical decisions to be made in situations where fracture mechanics is currently insufficiently developed to be of service. (auth) (UK)

**17280** LINEAR ELASTIC FRACTURE MECHANICS IN U. K.: WORK OF THE BISRA FRACTURE TOUGHNESS (HIGH STRENGTH STEELS) COMMITTEE. Cottrell, C. L. M. (Bristol Aerojet Ltd., Eng.); May, M. J. pp B1-12 of Practical Fracture Mechanics for Structural Steel. /Dobson, M. O. (ed.). London; Chapman and Hall, Ltd. (1969).

From Symposium on Fracture Toughness Concepts for Weldable Structural Steel, Risley, England. See CONF-690440.

The background to the formation of, and the current work of, the BISRA (British Iron and Steel Research Association) Fracture Toughness (High Strength Steels) Committee are reviewed. Details are given of the main conclusions arising from the collaborative fracture toughness testing programmes carried out by members of the Committee. This has guided the Committee in drafting a proposed British Standard for "Plane Strain Fracture Toughness ($K_{Ic}$) Testing." (auth) (UK)

**17281** CRACK OPENING DISPLACEMENT: A REVIEW OF PRINCIPLES AND METHODS. Burdekin, F. M. (Sandberg, London). pp C1-12 of Practical Fracture Mechanics for Structural Steel. /Dobson, M. O. (ed.). London; Chapman and Hall, Ltd. (1969).

From Symposium on Fracture Toughness Concepts for Weldable Structural Steel, Risley, England. See CONF-690440.

A description is given of the theoretical background leading to the concept of crack opening displacement (C.O.D.). This is divided into considerations of the relationship between applied stresses or strains, crack length and crack opening displacement deformation, and of critical C.O.D. as a measure of fracture toughness. It is concluded that the C.O.D. approach is entirely compatible with both linear elastic fracture mechanics and transition temperature concepts. The important factors which must be reproduced in fracture tests to obtain a representative measure of critical C.O.D. for elements of a structure are discussed. Particular attention is drawn to effects of thickness, strain rate, and metallurgical changes by welding. A discussion of techniques for C.O.D. measurement is included, as well as a summary of the application of the approach to calculation of critical defect sizes. (auth) (UK)

**17282** THE APPLICATION OF CRACK OPENING DISPLACEMENT MEASUREMENTS TO LARGE SCALE TEST BEHAVIOUR. Cowan, A.; Kirby, N. (United Kingdom Atomic Energy, Culcheth, Eng.). pp D1-27 of Practical Fracture Mechanics for Structural Steel. /Dobson, M. O. (ed.). London; Chapman and Hall, Ltd. (1969).

From Symposium on Fracture Toughness Concepts for Weldable Structural Steel, Risley, England. See CONF-690440.

Tests to failure were made on 5 ft diameter × 1 in. thickness steel pressure vessels containing longitudinal through-thickness defects of 6 to 24 in. in length. Continuous crack opening displacement (C.O.D.) measurements up to the point of failure showed that, on steels of yield strengths from 15 to 30 tons/$in^2$, good agreement exists with the C.O.D. values predicted from theoretical considerations. Well defined values of critical C.O.D. at failure could not be distinguished in either pressure vessels or notched bend specimens cut from the vessels when there was appreciable slow tearing before the initiation of unstable fracture. Under more brittle conditions critical values of C.O.D. could be defined more precisely and there was better agreement between critical values in bend specimens and vessels. Some of the differences in behavior persisting under these brittle conditions may be due to the effects of size and notch acuity. Until the reasons for these differences can be resolved, it is suggested that allowance be made for them in defining values of critical C.O.D. in bend tests to be used in determining specification values for structures. The failure stress of the vessels can be predicted to an accuracy of ±25% from the critical C.O.D. measured in bend specimens. Slightly better accuracy is obtained when com-

parison is limited to conditions where vessels and bend specimens show only cleavage initiation. It is these brittle conditions, corresponding to Charpy energies of less than 5 ft-lb, which are of practical interest in defining the acceptable level of toughness necessary in a structure. (auth) (UK)

**17283** DYNAMIC FRACTURE TOUGHNESS MEASUREMENTS (A RESUME OF SOME EXPERIMENTS). Edmondson, B.; Formby, C. L.; Stagg, M. S. (Central Electricity Generating Board, Berkeley, Eng.). pp E1-5 of Practical Fracture Mechanics for Structural Steel. /Dobson, M. O. (ed.). London; Chapman and Hall, Ltd. (1969).

From Symposium on Fracture Toughness Concepts for Weldable Structural Steel, Risley, England. See CONF-690440.

Experimental measurements of dynamic fracture toughness were carried out on large pressurised cylinders of mild steel. The effects of stress level and temperature on the conditions to keep a crack in motion were derived, and the results compared with small scale fracture mechanics measurements at strain rates allowing simulation of a fast moving crack. (auth) (UK)

**17284** THE USE OF CRITICAL CRACK OPENING DISPLACEMENT TECHNIQUES FOR THE SELECTION OF FRACTURE RESISTANT MATERIALS. Nichols, R. W. (United Kingdom Atomic Energy Authority, Culcheth, Eng.); Cowan, A.; Ingham, T.; Bundekin, F. M.; Elliott, D. pp F1-113 of Practical Fracture Mechanics for Structural Steel. /Dobson, M. O. (ed.). London; Chapman and Hall, Ltd. (1969).

From Symposium on Fracture Toughness Concepts for Weldable Structural Steel, Risley, England. See CONF-690440.

The results of collaborative tests made during 1967 to 1969 by the Crack Opening Displacement Applications (CODA) Group of the British Navy Department Advisory Committee on Structural Steels are presented. The theoretical and experimental basis for C.O.D. is reviewed, and the effect of specimen size and notch acuity on the critical C.O.D. and the development and assessment of C.O.D. measuring techniques are discussed, with particular reference to the establishment of a C.O.D. test which is compatible with the plane strain ($K_{IC}$) fracture toughness test. A recommended practice for C.O.D. testing is proposed. (auth) (UK)

**17285** BRITTLE FRACTURE INITIATION IN WELDED LOW STRENGTH STEELS. Dolby, R. E.; Egan, G. R.; Dawes, M. G.; Saunders, G. G.; Archer, G. L. (Welding Inst., London). pp G1-18 of Practical Fracture Mechanics for Structural Steel. /Dobson, M. O. (ed.). London; Chapman and Hall, Ltd. (1969).

From Symposium on Fracture Toughness Concepts for Weldable Structural Steel, Risley, England. See CONF-690440.

Recent research results concerned with initiation and propagation of brittle fracture in welded low strength steels are presented and their significance assessed. Values of dynamic fracture toughness suggest that they may be of limited practical significance when designing against fracture propagation. In respect of fracture initiation, embrittlement mechanisms in heat affected zone (HAZ) regions are considered, together with the techniques and problems associated with the determination of HAZ toughness. Aspects of specimen design for the determination of weld metal toughness are discussed. (auth) (UK)

**17286** LINEAR ELASTIC FRACTURE MECHANICS FOR THICK-WALI ED, WELDED STEEL PRESSURE VESSELS. MATERIAL PROPERTY CONSIDERATIONS. Wessel, E. T. (Westinghouse Research Labs., Pittsburgh). pp H1-44 of Practical Fracture Mechanics for Structural Steel. /Dobson, M. O. (ed.). London; Chapman and Hall, Ltd. (1969).

From Symposium on Fracture Toughness Concepts for Weldable Structural Steel, Risley, England. See CONF-690440.

The applicability of linear elastic (plane-strain) fracture mechanics to heavy-walled, welded pressure vessels is reviewed from the material characteristics viewpoints. The pertinent fracture mechanics material parameters of $K_{Ic}$ fracture toughness and fatigue crack growth rates are presented for some typical pressure vessel materials (ASTM A533 Grade B, Class 1 steel and weldments, and ASTM A216 Grade WCC, cast steel). The plane-strain toughness of these materials exhibits a strong temperature dependence, giving rise to high levels of toughness in the temperature range of practical interest. This high toughness, properly utilized, assures a high degree of fracture safety in pressure vessels constructed of these materials. (auth) (UK)

**17287** NOTCH DUCTILITY, DESIGN AND THE SPECIFICATION OF PERMISSIBLE DEFECT SIZES IN WELDED METAL STRUCTURES. Wells, A. A. (Queen's Univ., Belfast, Ireland). pp I1-16 of Practical Fracture Mechanics for Structural Steel. /Dobson, M. O. (ed.). London; Chapman and Hall, Ltd. (1969).

From Symposium on Fracture Toughness Concepts for Weldable Structural Steel, Risley, England. See CONF-690440.

Insofar as the goal of much fracture research is to facilitate the economic design of fracture-proof structures it is argued that the first consideration is the fabrication process, in terms of the sizes and distributions of incorporated defects at the time when these have been reduced to an economic minimum. The next consideration is notch ductility of parent metal and welded joints, and upon this will depend the design criteria to be adopted. It is further argued in this respect that there should be two alternatives, distinguishing the plane stress and plane strain modes of operation. The implementation of such philosophy would permit the specification of permissible defect sizes, in a format prepared in combination by fabricators, inspectors and researchers, and the paper discusses how such might strive for rigour, in combination with flexibility and practical simplicity of operation. (auth) (UK)

**17288** COUPLING OF FRACTURE MECHANICS AND TRANSITION TEMPERATURE APPROACHES TO FRACTURE-SAFE DESIGN. Loss, F. J.; Pellini, W. S. (Naval Research Lab., Washington, D. C. pp J1-35 of Practical Fracture Mechanics for Structural Steel. /Dobson, M. O. (ed.). London; Chapman and Hall, Ltd. (1969).

From Symposium on Fracture Toughness Concepts for Weldable Structural Steel, Risley, England. See CONF-690440.

The effect of mechanical constraint on the transition temperature features for steels of thick section is examined in the framework of linear elastic fracture mechanics $K_{Ic}$ and $K_{Id}$ tests and the Dynamic Tear (DT) test. It is demonstrated that steels of fracture toughness and yield strength levels representative of the A533-B type continue to exhibit a transition to high fracture toughness in thick sections. The distinguishing feature of thick sections is a size effect involving a shift of the transition temperature mid-point of the order of 60°F. The DT test defines a limiting transition temperature region, which can be divided into three parts: a low temperature regime in which plane strain fracture mechanics is applicable, a higher temperature regime which is beyond the limits of fracture mechanics definition and is relatable to crack arrest conditions of the FTE (fracture transition elastic) type, and a final regime involving large plastic deformation in association with the fracture. The relatively narrow temperature span of the plane strain regime above the NDT (nil ductility transition) temperature indicates practical difficulties in the direct application of fracture mechanics tests due to requirements for $K_{Ic}$ and $K_{Id}$ test specimens of large dimensions. A practical solution to the use of fracture mechanics principles may be obtained by considering the temperature-dependence aspects of the $K_{Ic}$ and $K_{Id}$ parameters. In general, the applicability of this approach is limited to temperatures below the FTE. If structural operation cannot be confined to temperatures above FTE, the Fracture Analysis Diagram (FAD) procedure, which is extended to thick sections, is recommended as the best available engineering approach. The Drop Weight-NDT and FAD procedures are analysed in terms of fracture mechanics aspects. (auth) (UK)

**17289** COMMENT ON CURRENT AND PROPOSED BRITISH STANDARD REQUIREMENTS FOR NOTCH DUCTILITY. Cotton, H. C.; Thomas, D. B. J. (British Petroleum Co., Ltd., London). pp K1-16 of Practical Fracture Mechanics for Structural Steel. /Dobson, M. O. (ed.). London; Chapman and Hall, Ltd. (1969).

From Symposium on Fracture Toughness Concepts for Weldable Structural Steel, Risley, England. See CONF-690440.

Current and proposed British Standard requirements for notch ductility are based on the accumulated data derived from the series of Wells Wide Plate Tests conducted at The Welding Institute. Crack Opening Displacement Tests indicate that the results of some of the Wells Wide Plate Tests may have been influenced by the properties of the weld metal and heat affected zones. The use of Crack Opening Displacement Tests to examine various critical zones in weldments is reported. (auth) (UK)

**17290** AN ENGINEERING APPROACH TO FRACTURE MECHANICS. Irvine, W. H.; Quirk, A. (United Kingdom Atomic Energy Authority, Risley, Eng.). pp L1-16 of Practical Fracture Mechanics for Structural Steel. /Dobson, M. O. (ed.). London; Chapman and Hall, Ltd. (1969).

From Symposium on Fracture Toughness Concepts for Weldable Structural Steel, Risley, England. See CONF-690440.

A formula, based on the tensile properties and Charpy V notch energy of the material, is presented for calculating the critical length of defects. It is shown how this approach is coupled with crack propagation data, and a pressure test, to provide a periodic

inspection technique. For a structure, such as a pressure vessel in which the critical crack length may vary over the operating temperature range, a minimum temperature/pressure relation is shown such that the risk of failure at start-up or shut-down is no greater than during normal operation. (auth) (UK)

**17291** RECENT WORK ON FLAW BEHAVIOUR IN PRESSURE VESSELS. Duffy, A. R.; Eiber, R. J.; Maxey, W. A. (Battelle Memorial Inst., Columbus, Ohio). pp M1-34 of Practical Fracture Mechanics for Structural Steel. /Dobson, M. O. (ed.). London; Chapman and Hall, Ltd. (1969).

From Symposium on Fracture Toughness Concepts for Weldable Structural Steel, Risley, England. See CONF-690440.

The results of full-size experiments on 12 to 30 inch diameter pipe employing through-wall and surface flaw defects are compared with empirical predictions of failure stresses. Two empirical relationships are discussed. These are based on (a) a fracture mechanics $K_c$ criterion and (b) a large scale yielding criterion. Limitations and regions of applicability are discussed. The results indicate reasonably good agreement between the predicted results and the full-scale vessel results. A brief discussion of Crack Opening Displacement (C.O.D.) results from ductile pipe experiments is also presented. Because of the very low slope of the C.O.D. versus pressure plot as the failure pressure is reached, it was concluded that C.O.D. values representing ductile behaviour are not useful. The behaviour of flaws during hold periods and subject to high stress low cycle fatigue is described. For the materials and flaw sizes investigated the long hold period at a constant stress produced failure of flaws at a stress level approximately 95 per cent of the straight-away to failure pressure. The high stress low cycle fatigue data available indicate that the same critical crack size is obtained in the ductile materials investigated whether the pressure is cycled to grow the crack to failure or whether the final crack length in the form of an artificial defect is pressured straight to failure. The experiments on vessels indicate that the conditions for the leak or a break of a surface flaw are dependent upon the length of the flaw relative to the critical through wall flaw size at the failure pressure. If the surface flaw crack length is greater than the through wall crack length at the failure stress, a break will occur. If the surface flaw length is less than the through wall crack length at the failure stress then a leak will occur. Thus the through wall crack length curve is the dividing line between leaks and breaks with the breaks occurring above the line and the leaks below. A short discussion is included on the conditions controlling the arrest of a fracture. While considerable research is needed to understand all the aspects of the problem, some information has been developed on the minimum stress level for propagation of ductile fracture in A106B (plain carbon steel) pipe. The results based on a series of full-scale experiments indicate that shear fractures require a stress level greater than approximately 12,000 psi to sustain ductile crack propagation in the pipe size and material examined. (auth) (UK)

**17292** GEOMETRICAL ASPECTS OF THE FAILURE OF CYLINDRICAL PRESSURE VESSELS. Lazzeri, L. (CNEN, Rome). pp N1-6 of Practical Fracture Mechanics for Structural Steel. /Dobson, M. O. (ed.). London; Chapman and Hall, Ltd. (1969).

From Symposium on Fracture Toughness Concepts for Weldable Structural Steel, Risley, England. See CONF-690440.

A formula is developed connecting the failure conditions in longitudinally slit cylinders with geometrical parameters and material properties. This formula $K_c = \sqrt{\pi c_c}\,\sigma_h\,[1 + (0.29 - 0.09 \ln c_c^2/Rt)c_c^2/Rt]$ is in agreement with mild steel experimental results, regardless of flaw length or other geometrical factors. (Note—$K_c$ = critical stress intensity factor; $c_c$ = effective crack length; $\sigma_h$ = nominal hoop stress on vessel at failure; R = cylinder radius; t = cylinder thickness). (auth) (UK)

**17293** ACOUSTIC EMISSION INVESTIGATIONS DURING PRESSURE VESSEL TESTING AT REACTOR MATERIALS LABORATORY, CULCHETH [UNITED KINGDOM ATOMIC ENERGY AUTHORITY]. Nielsen, A. (Danish Central Welding Inst., Copenhagen). pp O1-10 of Practical Fracture Mechanics for Structural Steel. /Dobson, M. O. (ed.). London; Chapman and Hall, Ltd. (1969).

From Symposium on Fracture Toughness Concepts for Weldable Structural Steel, Risley, England. See CONF-690440.

Acoustic emission during the pressurisation of steel pressure vessels was investigated using transducers located on the vessel surface. Emissions were detected from the start of pressurisation. After rising to a maximum at relatively low pressures they subsequently tended to decrease and decayed rapidly when pressure was held constant. In repeated pressurisations there was virtually no acoustic activity until the maximum recorded previous pressure was exceeded. Introduction of artificial defects in the vessels raised the level of acoustic activity, but the general pattern of behaviour was unchanged. No significant rise in activity was detected during the immediate approach to failure. (auth) (UK)

**17294** FAILURE CRITERIA FOR THROUGH-CRACKED VESSELS. Hahn, G. T.; Sarrate, M. (Battelle Memorial Inst., Columbus, Ohio). pp P1-15 of Practical Fracture Mechanics for Structural Steel. /Dobson, M. O. (ed.). London; Chapman and Hall, Ltd. (1969).

From Symposium on Fracture Toughness Concepts for Weldable Structural Steel, Risley, England. See CONF-690440.

A more unified picture of the various approaches represented at the conference e.g., LEFM, plasticity corrected fracture toughness, COD, the flow stress criterion, as well as the FAD and transition temperature approach is presented. These concepts are fitted into a common framework consisting of 3 failure categories: (1) linear elastic behaviour, (2) non-linear elastic behaviour, and (3) plastic instability behaviour. The dividing line—in terms of the crack length 2c, the toughness $K_c$, and the yield stress Y—between Categories (1) and (2) is tentatively placed at $(K_c/Y)^2\,1/c \approx 1.2$, and between Categories (2) and (3) at $(K_c/Y)^2\,1/c \approx 7$. Thus, for ordinary structural steels and flaw sizes, Categories (1), (2), and (3) tend to correspond with failure below, at and above the fracture mode transition. The paper touches on the theoretical connection between $K_c$ and COD and the problems of measuring these toughness indices. It appears that $K_c$ lends itself to characterising relatively brittle materials, e.g. $(K_c/Y) \lesssim 1.5\sqrt{\text{in.}}$, that tend to be associated with Category (1) failures, while COD is well suited for tougher materials, e.g., $(K_c/Y) \gtrsim 1.2\sqrt{\text{in.}}$, and Category (2) failures. In Category (3), critical flaw sizes and hoop stress values are virtually insensitive to either $K_c$ or COD, and good predictions can be derived from the flow strength of the material. Finally, some of the uncertainties connected with existing treatments of bulging and the plasticity corrections are enumerated. (auth) (UK)

**17295** DEFORMATION OF TYPE 5VMTs [NIOBIUM-BASE] ALLOYS. Okhrimenko, Ya. M.; Troitskii, V. P.; Koterev, I. A.; Pyl'nikov, V. I. Izv. Vyssh. Ucheb. Zaved., Chern. Met.; No. 5, 75-8(1969). (In Russian).

The deformation of Nb-base alloys containing up to 0.1% C was investigated. The coefficient of reduction was determined experimentally and the influence of C additions on the processing technique, mechanical properties, and heat treatment practice was examined. C additions up to 0.1% had almost no influence on strength and plastic properties, and none on forging characteristics at 1100 to 1350°C. The commencement of recrystallization was somewhat retarded with increasing C content. (Metals Abstr.)

**17296** DEBYE TEMPERATURE AND THE COEFFICIENT OF THERMAL EXPANSION FOR V AND Nb BY X-RAY DIFFRACTION. Linkoaho, M.; Rantavuori, E. (Technical Univ. of Helsinki, Otaniemi, Finland). Phys. Status Solidi; 37: K89-91(1 Feb 1970).

Debye–Waller coefficients were determined by measuring integrated intensities of x-ray reflections of V and Nb powders at 300, 80, and 4°K. Changes in the coefficients between 300 to 4°K and 80 to 4°K and thermal expansion coefficients are tabulated together with calculated Debye temperatures. (D.L.C.)

**17297** EFFECT OF REPEATED PLASTIC DEFORMATION ON THE DAMPING OF ULTRASOUND IN MAGNESIUM AND MAGNESIUM–2.8 PERCENT NEODYMIUM. Zusman, L. L.; Rokhlin, L. L. Fiz. Khim. Obrab. Mater.; No. 4, 124-7(Jul-Aug 1969). (In Russian).

The effect of repeated plastic deformation on the damping of ultrasound in Mg and Mg–2.8% Nd of the kind frequently used as material for sound guides and ultrasonic delay lines was studied. Even after very slight degrees of deformation in a standard press (0.1 to 0.2%) the damping of ultrasound in both materials increased sharply, making them unfit for the envisaged service. Further deformation led to a still greater damping effect. Holding at room temperature for long periods after such treatment partly restored the original properties, but the damping was still worse than in the annealed state. (Metals Abstr.)

**17298** RESISTANCE STABILITY OF ELECTRON-BEAM VAPOURIZED TANTALUM LAYERS. Wolf, Gerhard. Wiss. Z. Tech. Hochsch. Karl-Marx-Stadt; 10: 181-3(1968). (In German).

Layers of Ta 300 to 2700 Å in thickness were prepared using an electron-beam evaporation technique. The layers were then aged in air at 300°C and the variation with time of the resistance

determined. The resistance was found to increase steadily with time. The relative increase in resistance grew with increased evaporation rate and decreased layer thickness. Comparison of the results with published values for cathode-vaporized Ta layers shows that the electron-beam vaporized layers are more stable. (Metals Abstr.)

**17299** INTERNAL FRICTION IN ZIRCONIUM. Semenikhin, A. N. (Moscow Engineering-Physics Inst.). Fiz. Metal. Metalloved.; 28: 749-51(Oct 1969). (In Russian).

Plastic deformation changes the mechanical and physical properties of metals as a result of the formation of point defects, their accumulations, and dislocations. If deformation occurs at comparatively low temperature, most of these defects (frozen) disappear during subsequent heating. Elimination of the defects restores the properties of the deformed metal. A study of the restoration of internal friction after plastic deformation offers data on the rate of disappearance of the defects and their interaction with dislocations. The study was performed on zirconium. (tr-auth)

**17300** THE STRESSES AND STRAINS SET UP WHEN BUTT JOINTS IN SHEET NIOBIUM ARE WELDED. Gurevich, S. M. (Institut Elektrosvarki, Kiev); Nerodenko, M. M.; Asnis, A. E.; Prokhorenko, V. M. Automat. Weld. (USSR) (Engl. Transl.); 22: 35-7(Apr 1969). (In Ukrainian).

Translated from Avtomat. Svaraka; 22: 33-4(Apr. 1969).

Determination of the residual stresses which form during welding of sheet niobium specimens, using an extensiometer, is described. The distribution of the longitudinal and transverse residual stresses is established. The effects of annealing temperature on residual stress relieving are examined. It was found that during annealing above 1200 deg C, the residual stresses are reduced by about 90 per cent. (IAA)

**17301** STUDIES ON COPPER–ZIRCONIUM SINTERED MATERIALS [FOR WELDING ELECTRODES]. Tassewa, Sneshana. ZIS (Zentralinst. Schweisstech.)-Mitt.; 11: 1064-76(Jul 1969). (In German).

The powder metallurgical preparation of Cu–Zr sintered materials containing up to 1.5 wt. % Zr was studied and the products examined as possible spot welding electrodes. It was found that even with Zr additions <1.0 wt % the mechanical strength of the product was greatly increased without a corresponding significant reduction in electrical conductivity. (Metals Abstr.)

**17302** INTERNAL FRICTION AND MECHANICAL PROPERTIES IN AIR AND IN HYDROGEN OF Nb–5Mo–N ALLOYS. Geschier, Roland; Vercaemer, Claude; Guille, Jean; Clauss, Auguste (Strasbourg Univ.). Compt. Rend., Ser. C; 270: 290-3(19 Jan 1970). (In French).

The Snoek peak due to nitrogen as well as the mechanical properties at room temperature in air and in hydrogen of Nb–5Mo–N alloys were studied. An extreme brittleness was observed in dry hydrogen. The presence of water vapor in hydrogen remove this embrittlement phenomenon. (auth) (France)

**17303** RELATIONS BETWEEN THE HEIGHT OF THE INTERNAL FRICTION PEAKS DUE TO DISLOCATIONS IN POLYCRYSTALLINE MOLYBDENUM AND THE VARIOUS STEPS OF THE STRESS STRAIN CURVE AT 20°C. Rieu, Georges; de Fouquet, Jacques; Nadeau, Andre (Ecole Nationale Superieure de Mecanique et d'Aerotechnique, Poitiers, France). Compt. Rend., Ser. C; 270: 287-9(19 Jan 1970). (In French).

Measurements of internal friction made on polycrystalline molybdenum of purity 4 N 5, at frequencies of 19 kHz showed a relation existing between the height of the peaks observed between 77 and 700°K and the various steps of the stress strain curve at 20°C. A discontinuous spectrum of $P\beta$ peaks was found, the formation of the peaks through the elastic domain and its evolution as a function of the dislocation density were studied. (auth) (France)

**17304** DIFFUSION AND SOLUBILITY OF GOLD IN POTASSIUM. Smith, F. A.; Barr, L. W. (Atomic Energy Research Establishment, Harwell, Eng.). Phil. Mag.; 21: 633-8(Mar 1970).

The diffusion coefficient and solubility of gold in potassium have been measured between 6 and 53°C. The temperature dependence of the diffusion coefficient is given by: $D = (1.29 \pm 0.6) \times 10^{-3} \exp(-3.23 \pm 0.3/RT)$ $cm^2\ sec^{-1}$ and the solubility by the equation: $S = (2.2^{+}_{-}) \times 10^{3} \exp(-7.8 \pm 0.8/RT)$ at. %, where the activation energies are in kcal $mol^{-1}$. (auth) (UK)

**17305** SOME PROPERTIES OF THE RHENIUM (0001) SURFACE. Dooley III, George J.; Haas, T. W. (Aerospace Research Labs., Wright Patterson AFB, Ohio). Surface Sci.; 19: 1-8(Jan 1970).

The Re(0001) surface has been studied using low energy electron diffraction (LEED) and Auger electron spectroscopy. Auger electron spectroscopy verifies that the surface can be cleaned by simple heating in vacuum. The LEED results show that the clean surface has the structure expected of a (0001) plane. Gas adsorption studies showed this surface to be inert to all gases studied except oxygen. Oxygen gives a $(2 \times 2)$ diffraction pattern. (auth)

**17306** THE PRESSURE-RESISTANCE BEHAVIOUR OF SOME YTTERBIUM–EUROPIUM ALLOYS. King, E. (Atomic Energy Research Establishment, Harwell, Eng.); Harris, I. R. J. Less-Common Metals; 20: 237-44(1970).

The effect of pressures on electrical conductivity has been investigated for a series of alloys in the Yb–Eu system up to 80 kbar, and for elemental Yb and Eu up to 110 kbar. The addition of Eu caused the maximum in the resistance–pressure curve of Yb (at 39.4 kbar in pure Yb) and in moving to lower pressures it diminished rapidly in height with Eu concentrations up to about 40% Eu. The resistance peak is still discernable in the bcc alloys up to, and including the 90% Eu alloy. (auth)

## *Structure and Phase Studies*

*Refer also to abstracts 17380 and 18034.*

**17307** (CEA-CONF-1441) COMBINED SCANNING ELECTRON MICROSCOPY AND X-RAY MICROANALYSIS IN METALLURGICAL NUCLEAR APPLICATIONS. Meny, L.; Champigny, M. (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). 1969. 23p. (In French). (CONF-690715-1). Dep. CFSTI (U. S. Sales Only).

From 4th National Conference on Electron Microprobe Analysis, Pasadena, Calif.

Results of examinations of metallic nuclear materials using various commercial instruments are presented. Information is included on the lamellar structure of Al–Mg alloy, identification of intermetallic $UMo_{10}\ Sn_{0.25}$, precipitates in steel, structure of intermetallic $ZrCu_{1.6}\ Mo_1$ alloy, fracture specimen examination using electron microscope, and metallography methods using replicas. (J.R.D.)

**17308** (IS-T-328) EFFECT OF SOLUTES FROM THE SIXTH PERIOD OF THE PERIODIC TABLE ON THE MELTING POINT AND THE ALLOTROPIC TRANSFORMATION TEMPERATURE OF PRASEODYMIUM. Griffin, Richard Bruce (Ames Lab., Iowa). Nov 1969. Contract W-7405-eng-82. 138p. Dep. CFSTI.

Thesis.

The effects of the elements of the sixth period, Cs through Bi excluding the lanthanides, on the melting point and the allotropic transformation temperature of Pr were investigated. The equilibrium diagrams were studied at the Pr-rich end by differential thermal, chemical, metallographic and x-ray techniques. (auth)

**17309** (LA-4230-tr) EFFECT OF O ON THE [ISOMORPHOUS] UC PHASE-EXISTENCE DOMAIN. Boncoeur, M.; Magnier, P.; Accary, A. Translated for Los Alamos Scientific Lab., N. Mex., from J. Nucl. Mater.; 28: 233-4(1968). 3p. Dep. CFSTI.

An abstract of this paper, prepared from the original language, appeared as NSA 23: 8219. (auth)

**17310** (ORNL-TM-2866) COMPUTER PROGRAM FOR THE SIMULATION OF SOLID SOLUTIONS FROM X-RAY DATA. Williams, R. O. (Oak Ridge National Lab., Tenn.). Mar 1970. Contract W-7405-eng-26. 41p. Dep. CFSTI.

The structure of binary solid solutions may be simulated in the sense that one can generate a finite model of two kinds of atoms which will reproduce in several shells average populations which are in agreement with those deduced from diffuse x-ray measurements. The model should be fairly large to give good statistics, but this can result in appreciable computing times. The present program uses efficient algorithms with nearly optimum coding which result in its being 100 times faster than a previous program. The documentation and characterization of this program are given. (auth)

**17311** RESOLUTION OF (110) ATOMIC PLANES OF TUNGSTEN IN THE ELECTRON MICROSCOPE. Hugo, J. A.; Phillips, V. A. (General Electric Research and Development Center, Schenectady, N. Y.). Metallography; 2: 395-7(Dec 1969).

A technique involving phase contrast used to resolve the atomic planes of W is described. High-purity single crystal W was pre-

pared and examined using an electron microscope. Resulting micrographs are presented as illustrations. (J.R.D.)

**17312** METHOD FOR DETERMINATION OF PHASE BOUNDARIES OF UNIVARIANT EQUILIBRIA IN MULTICOMPONENT SYSTEMS. Aldinger, Fritz (Max-Planck-Institut fuer Metallforschung, Stuttgart). Metallography; 2: 363-74(Dec 1969). (In German).

With a combination of x-ray and quantitative metallographic techniques it is possible to compute the composition of the phases of univariant phase equilibria. In a n-component system only measurements on n samples of the univariant equilibria must be carried out. This corresponds to an enormous reduction of the number of alloys to be investigated as compared to previous methods The application of the method to the determination of an isothermal four phase equilibria in the quaternary system copper-silver-zinc-cadmium is described. The computed values agree well with data obtained by conventional methods. (auth)

**17313** STUDIES ON TRANSFORMATION AND MORPHOLOGY OF TITANIUM ALLOYS: OMEGA PHASE IN Ti–Mo ALLOYS. Ikawa, Hiroshi; Shin, Shigeo, Morikawa, Masaki (Osaka Univ.). Technol. Rep. Osaka Univ.; 19: 449-66(Oct 1969).

Transmission electron microscopic observation of morphology of $\omega$ phase in Ti–Mo alloy which is a typical $\beta$ isomorphous type is reported. It was found that the hardness of Ti–12 ~ 16 wt % Mo alloy increases rapidly by aging at 450°C for 10 min. Such an increase is due to precipitation of $\omega$ phase. The omega prime in the $\beta$ quenched specimens does not contribute to increasing of the hardness. If the size of $\omega$ phase becomes larger than about 100 Å, the hardness increases. The $\omega$ phase precipitates with 4 orientations and the formation is ellipsoid that major axis is parallel to $\langle 111\rangle_\beta$ direction. The orientation relation between $\omega$ phase and matrix $\beta$ phase is as follows, $(11\bar{2}0)_\omega \parallel (110)_\beta$, $\langle 0001\rangle_\omega \parallel \langle 111\rangle_\beta$. By the technique of the dark field image, one variant $\omega$ phase can be destinguished from another $\omega$ phase with different variants. In Ti–Mo alloy aged at 450°C, the size of major axis of ellipsodic $\omega$ phase is about 2000 Å. The $\omega$ phase in Ti–Mo alloys is ellipsoid regardless of the aging temperature and solute concentrations. (auth)

**17314** TERNARY COMPOUNDS OF THE $NaZn_{13}$ TYPE AND RELATED TYPES IN THE SYSTEMS (La, Ce, Pr, Nd, Sm, Eu, Gd)–Ni–Si AND (La, Ce)–(Fe, Co)–Si. Bodak, O. I.; Gladyshevskii, E. I. (Lvov State Univ.). Dopov. Akad. Nauk Ukr. RSR, Ser. A; 12: 1125-9(1969). (In Ukrainian).

X-ray diffraction analysis of the compounds was conducted for the systems La–Ni–Si (0 to 10 at. % La) and in the systems (La,Ce)–(Fe,Co)–Si (8.14 at. % La or Ce) and R–Ni–Si (8.14 at. % R), where R = Ce, Pr, Nd, Sm, Eu or Gd. The existence of 17 compounds with the structure of the $NaZn_{13}$ type (cubic) and related types (tetragonal) was established. (auth)

**17315** ALLOY CHEMISTRY OF $\sigma(\beta$-U)-RELATED PHASES. III. $\sigma$-PHASES WITH NON-TRANSITION ELEMENTS. Hansen, R. C.; Raman, A. (Louisiana State Univ., Baton Rouge). Z. Metallk.; 61: 115-20(Feb. 1970).

$Nb_2Al(\sigma)$ forms continuous series of solid solutions with $Ta_2Al(\sigma)$ and $Nb_3Rh_2(\sigma)$, and dissolves about 14 at.% Zr. The lattice parameters do not change when Zr is dissolved in the $\sigma$-lattice. A ternary $\sigma$-phase occurs in a narrow region in the Ti–Mo–Al system and is designated by the formula $Ti_{1.5}Mo_{1.5}Al_2$. Its lattice parameters (a = 9.667 Å; c = 5.018 Å) are similar to those of the $\sigma$-phase solid solution in the alloy $Nb_{35}Mo_{32.5}Al_{32.5}$. The $\sigma$-phases containing substantial amounts of nontransition elements are postulated to occur in the free electron concentration range 4 to 4.7. The radius ratio of component atom kinds is close to unity and in general elements which would bring down the radius ratio to 1 appear to dissolve more in the $Nb_2Al$ $\sigma$-phase. A ternary $\mu$-phase with largest lattice constants among known $\mu$-phases (a = 5.296 Å; c = 28.73 Å: Zr-rich; a = 5.227 Å; c = 28.30 Å: Al-rich) occurs as a solid solution between the compositions $Zr_5Nb_2Al_8$ and $Zr_7Nb_3Al_7$. Another ternary phase, ZrNbAl, of undetermined structure is also found in the Zr–Nb–Al system. A $TiAl_3$-type ternary phase (a = 3.866 Å; c = 8.673 Å) occurs in the central region of the $ZrAl_3$–"$MoAl_3$" section, $ZrAl_2$ ($MgZn_2$) dissolves about 61 at. % Mo and extends deeply towards $ZrMo_2$ ($MgCu_2$). While the Zr–Al binary phases dissolve appreciable amounts of Nb, only limited solubilities of Mo in the phases are observed. (auth)

**17316** SOME OBSERVATIONS ON THE ANNEALING OF INDIUM. Dasarathy, Cuppam (British Steel Corp., Port Talbot, Eng.). Z. Metallk.; 61: 121-3(Feb 1970).

Specimens of indium of 99.9% purity, deformed in compression by 30% at –193°C were found to be recrystallized on reaching 20°C. These specimens were annealed at 40 and 50°C for times up to 17 hours. During annealing from 0 to 1 hour at 40 and 50°C, the conditions were favorable for the annihilation of existing annealing twins. Annealing from 1 to 3 hours, produced conditions favorable for the generation of fresh twins. However, further annealing from 3 to 7 hours produced conditions favorable for twin annihilation. Examples were found to illustrate the sequence of changes leading to the shrinkage of annealing twins. Annihilation of twins was also observed to occur when relatively large and twin free grains grew at the expense of several small grains containing twins. The microstructure of all the specimens examined showed the presence of certain diffuse sub-boundaries within the grains. It is suggested that these sub-boundaries may correspond to the position of low angle boundaries present in the deformed state, being revealed by effects due to segregation of trace impurities to these regions. (auth)

**17317** SOLID–LIQUID PHASE EQUILIBRIA IN THE SODIUM–RUBIDIUM ALLOY SYSTEM. Goates, J. Rex; Ott, J. Bevan; Hsu, Chen C. (Brigham Young Univ., Provo, Utah). Trans. Faraday Soc.; 66: 25-9(Jan 1970).

Thermal methods were used to determine with high precision, the solid–liquid phase equilibria diagram for the sodium–rubidium system. The results differed greatly from those of others, especially near the eutectic composition where differences in melting points as large as 25°K occurred. A search was made for possible intermetallic compounds (especially $Na_2Rb$). Neither slow temperature cycling in the temperature range where compound formation could occur nor extended periods of annealing just above the eutectic temperature produced any evidence for compound formation. A 2:1 (sodium to rubidium) sample was subjected to 60,000 atm pressure. Again, no evidence was obtained for solid compound formation. (auth) (UK)

**17318** THE PHASE COMPOSITION OF AN IRON–CHROMIUM–NICKEL OXIDATION RESISTANT ALLOY CONTAINING NITROGEN. Zharkova, D. N.; Khmel'nova, S. V.; Yakovleva, E. F. Sb. Tr. Tsent. Nauch.-Issled. Inst. Chern. Met.; No. 66, 46-50(1969). (In Russian).

X-ray and chemical analyses were used to study the phase composition of an Fe–Cr–Ni cast alloy containing Cr 25, Ni 25, W 5, Mo 1, Nb 1.0, N 0.4, and C 0.1–0.4%. An electrochemical method was developed for separating and removing the intermetallic Z-phase from the Laves phase based on the Fe, Nb $\sigma$-phase, $Me_{23}C_6$, NbN, and Nb(NC) present in the alloy. The Z-phase contains Cr ~ 43, Fe ~ 38, Mn ~ 6, and Nb ~ 13 at.%. (Referativnyi Zh.)

**17319** INVESTIGATION OF THE INTERACTION OF THE COMPONENTS IN NICKEL–ZIRCONIUM–NITROGEN MELTS. Tripolitov, A. I.; Kryuchkov, O. N.; Stomakhin, A. Ya.; Filippov, A. F. Izv. Vyssh. Ucheb. Zaved., Chern. Met.; No. 5, 57-61 (1969). (In Russian).

The interaction of N with Ni–Zr melts was investigated. The solubility of N in Ni melts containing up to 5% Zr at 1550°C at a pressure of 1 atm was measured by the Sieverts method, and the heats of mixture of Zr with Ni-base alloys were determined in a high-temperature, calorimeter. The equilibrium concentration of Zr in the Ni–Zr was determined at 1550°C at a N pressure of 1 atm, and the interaction parameters of Zr with N in Ni alloys were calculated. (Metals Abstr.)

**17320** KNOWLEDGE OF THE IRON CORNER OF THE IRON–VANADIUM–CARBON SYSTEM. Ebeling, Reinhard; Wever, Hans; Arch. Eisenhuettenw.; 40: 551-5(Jul 1969). (In German).

The position of various boundary lines of the phase fields in the Fe–V–C system was established by the diffusion method and thermodynamic analysis; the occurrence of an Fe–V mixed carbide, $(Fe,V)_3C$, was confirmed by Debye–Scherrer photographs. The C activity was determined at 950, 1000, and 1050°C, and the isothermal phase diagram constructed for the Fe corner at 1000°C. (Metals Abstr.)

**17321** [THE EFFECT OF] HEAT-TREATMENTS [ON SEGREGATION] FOR COPPER AND COPPER ALLOYS. III. Cuivre, Laitons, Alliages; No. 110, 9-11(Jul-Aug 1969). (In French).

Dendritic segregation on cooling of Cu and Cu alloys is discussed, and effects of the resulting $\delta$-phase on the hardness and other properties of 6 to 15% Sn bronzes plotted. Homogenizing annealing treatments for Cu–Sn, Cu–Be, and Cu–Ni–Zn alloys are described, and results obtained micrographically presented. (Metals Abstr.)

**17322** SUBSTITUTIONAL–INTERSTITIAL INTERACTIONS IN NIOBIUM–1 PERCENT ZIRCONIUM–OXYGEN ALLOYS. Miner, R. E.; Gibbons, D. F.; Gibala, R. (Case Western Reserve Univ., Cleveland). Acta Met.; 18: 419-28(Apr 1970).

The interaction between substitutional and interstitial atoms in

single crystals of niobium-zirconium-oxygen alloys has been investigated by an internal friction technique. A digital computer was employed to show that the 50 kHz internal friction spectra of alloys with 1.0 at. % Zr and 15 to 5300 ppM oxygen could be synthesized on the basis of five Debye peaks, two corresponding to the oxygen and nitrogen Snoek peaks and three extraordinary peaks resulting from the relaxation of substitutional-interstitial (s-i) defects. The synthesis was achieved on the basis of single relaxation time (theoretical breadth) Debye peaks. Measurements on ⟨100⟩-, ⟨110⟩- and ⟨111⟩-orientated specimens showed that the orientation dependence of all the relaxation processes was the same as that for the Snoek peaks. The s-i defect symmetry was, thereby, concluded to be either tetragonal or ⟨100⟩ orthorhombic. These results and the composition dependence of the five processes showed that the defects responsible for the extraordinary peaks observed are (1) an oxygen atom and (2) a nitrogen atom on nearest neighbor octahedral sites to a zirconium atom and (3) a pair of oxygen atoms on opposite nearest neighbor octahedral sites around a zirconium atom. (auth)

**17323** LEED STRUCTURES DUE TO INTERACTION OF CO AND $O_2$ WITH (0001) Re. Farnsworth, H. E.; Zehner, D. M. (Brown Univ., Providence). Surface Sci.; 17: 7-31(Sep 1969).

Exposures to CO in the range $1 \times 10^{-8}$ to $1 \times 10^{-2}$ torr-min at 20°C produced an adsorbed surface structure with fractional-order beams in the diffraction pattern, thus indicating a multiple-spaced adsorbed structure. The pattern was enhanced by mild heating at 425°C for 10 min but was weakened by further heating at 615°C for 30 min. Exposures of $1 \times 10^{-4}$ torr-min at temperatures of 615°C and 780°C resulted in more intense fractional-order patterns with some changes in the I-vs.-V curve for the (01) beam. Oxygen exposures at 20°C produced similar half-order patterns and after mild heating at 425°C the I-vs.-V curve for the $(0\frac{1}{2})$ beam was identical with that of the corresponding beam from the CO-exposed surface. However, the fractional-order patterns from the oxygen structure continued to increase with the temperature of previous vacuum heating to at least 1130°C, after which they decreased with increasing temperature of preceding heat treatment. Thus the oxygen structure was more tightly bound than the CO structure. The similar shapes of the I-vs.-V curves for the fractional order patterns suggest that in both cases the adsorbed atoms remain on the surface and result in similar double scattering. Oxygen exposures of $1 \times 10^{-4}$ torr-min at 780°C and 920°C resulted in a diffraction pattern containing integral-order beams only, whose intensities were more than three times those of the corresponding beams from the clean surface. This pattern indicates a ReO surface structure. CO exposures at 20°C caused a maximum increase in work function of 0.35 eV. A maximum increase in work function of about 0.55 eV was caused by $O_2$ exposures at 20°C while exposures at 600°C to 900°C caused increases as great as 1.5 eV. (auth)

**17324** LATTICE-PARAMETER RELATIONSHIPS IN TRANSITION-METAL LAVES PHASES. Rumball, W. M. (Atomic Energy of Canada Ltd., Chalk River, Ont.). J. Less-Common Metals; 20: 191-7(1970).

The application of the Pauling equation for atomic radii, r(I) − r(n) = 0.3 log n, to transition-metal $AB_2$ Laves phases (where Zr, Hf, and Ti constitute the "A" atoms) yields the same apparent valencies of "A" and "B" from crystallographic data, irrespective of whether the cubic or hexagonal allotropic modifications are considered. This enables the lattice parameters of one allotropic form to be calculated from the parameters of the other form to within about 0.2% of experimental values. The lattice parameters of Zr, Hf, and Ti Laves phases have been calculated for hitherto undiscovered allotropes where parameters of the other form are available. It is suggested that the observed smooth variation across the Periodic Table of the apparent valency for both A and B atoms might be attributed to varying amounts of electron transfer from B atoms to A atoms, or to a smooth change in the single-bond radii with increasing d-orbital contributions. (auth)

## *Radiation Effects*

*Refer also to abstracts 17360, 18020, 18511, 18661, and 18699.*

**17325** (CONF-690910–, pp 3-23) INFLUENCE OF NEUTRON SPECTRUM ON HELIUM ATOM GENERATION IN STAINLESS STEELS. Moteff, J. (General Electric Co., Cincinnati, Ohio. Nuclear Systems Programs).

The study of the effects of helium generation resulting from neutron irradiation increases in importance as new theories of void formation and subsequent embrittlement develop. Up until now, the opinion has been that only a rough calculation of the amount of helium atoms formed in $(n,\alpha)$ reactions could be made. Comparisons between calculated and directly measured quantities of helium are now in progress. Effective spectrum averaged cross sections or empirical differential cross sections (using cross section unfolding programs) may be obtained by irradiating high purity elements in several different reactor facilities where detailed information on the neutron spectrum is available (i.e., Monte Carlo calculations), and measuring directly the helium atom generation. Correction factors to the fission spectrum averaged cross sections are proposed which comprise an interim method for calculations of the helium atoms generated in various fast spectrum facilities. (J.R.D.)

**17326** (CONF-690910–, pp 24-37) FATIGUE SPECIMEN CAPSULES, EBR-II MARK B-7 SUBASSEMBLY. Beeston, J. M.; Ellingford, M. W.; Brinkman, C. R. (Idaho Nuclear Corp., Idaho Falls).

Design, fabrication, and operating experience from irradiation of fatigue specimen capsules in an EBR-II MARK B-7 subassembly are discussed. The effect of specimen size and shape, and of program criteria on the design is evaluated. Heat transfer considerations that influence the design are reviewed. The assembly to meet quality assurance of parts and performance, and the operating experience from 2864 MWd in EBR-II on one subassembly are given. The operating temperature of the specimens in sodium at 50 MW was about 400°C and in argon was 750°C. (auth)

**17327** (CONF-690910–, pp 157-64) ACHIEVING UNIFORM SPECIMEN TEMPERATURES IN AN IRRADIATION CAPSULE USING HEAT PIPES. Zielenbach, W. J.; Miller, N. E. (Battelle Memorial Inst., Columbus, Ohio).

Results of laboratory studies indicate that a lithium-filled annular heat pipe is feasible as a means of obtaining near isothermal conditions axially along the surface on the cladding of a short fuel sample in an in-pile fuel-irradiation capsule. At a 1500°C operating temperature the axial spread of temperatures was less than 20°C along a three inch length in an experiment simulating the irradiation capsule. The annular heat pipe would be incorporated into the current capsule configuration employed in the high-temperature-fuels program to achieve uniform specimen cladding temperatures of 1600 to 1900°C. (auth)

**17328** (CONF-690910–, pp 491-505) DAMAGE-FUNCTION ANALYSIS OF NEUTRON-ENERGY AND SPECTRUM EFFECTS UPON THE RADIATION EMBRITTLEMENT OF STEELS. Serpan, C. Z. Jr.; McElroy, W. N. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.).

Critical evaluations of irradiation effects data for steels exposed in different reactor environments depend upon fluence measurements that reflect the neutron population and the corresponding influence of damage mechanisms inherent to those neutron energy spectra. Models describing neutron damage in reactors were adjusted with data on mechanical property changes of A302-B steel irradiated at <450°F. This procedure yielded a damage function that more properly accounts for the energy dependence of damage. One major conclusion reached is that detailed as well as accurate neutron dosimetry measurements of fast and thermal fluxes, corrected to reactor operating temperatures, are necessary if good correlations among irradiation-effects data are to be obtained. This requirement applies to both experimental irradiations and irradiations at reactor component surveillance locations. The study has shown further that an independently derived damage function for irradiation of structural steels such as A302-B at <450°F is realistic and can be applied to new experimental data conforming to those conditions. The contributions of thermal and low-energy neutrons to the embrittlement process in low-alloy steel are shown to be of major importance to the interpretation of radiation-effects data. (auth)

**17329** (CONF-690910–, pp 506-15) USE OF NUCLEAR EXPLOSIONS FOR THE STUDY OF RADIATION DAMAGE PROCESSES. Carter, Robert L. (Los Alamos Scientific Lab., N. Mex. Missouri Univ., Columbia).

Information and theory are presented to support the thesis that the effects of high intensity neutron irradiation on the physical properties of solids can be conducted at N.T.S. in underground nuclear explosions. Discussions are included on the use of nuclear explosions, character of a nuclear bomb as a neutron source, mechanical problems of testing, parameters of radiation damage and annealing experiments, and parameters of direct energy conversion studies. (J.R.D.)

**17330** (IN–1335, pp 1-24) MATERIALS RESEARCH. (Idaho Nuclear Corp., Idaho Falls).

An investigation was concluded to determine the influence of hydrogen on the ductile and static load properties of several irradiated intermediate strength low alloy steels. The degree to which these properties were affected was generally found to be

dependent on strength level. Increasing the strength level as a result of heat treatment, cold work, or irradiation increased the extent to which those parameters were reduced per given hydrogen content. Physical property changes due to irradiation of beryllium are being monitored. Hafnium has been added to the program to monitor changes of the ATR absorber sections. Over 400 hourglass-shaped specimens of cladding and pressure vessel materials have been or are presently being irradiated for postirradiation elevated temperature fatigue testing. Specimens of type 304 stainless steel which were irradiated in argon at 750°C have been push-pull fatigue tested at 500°C in an argon environment. Within the scatter of the data, little difference is noted between fatigue properties of the irradiated 304 stainless and the unirradiated material. (auth)

**17331** (ORNL-4449, pp 165-213) MATERIALS DEVELOPMENT. Eatherly, W. P.; McCoy, H. E.; Weir, J. R. (Oak Ridge National Lab., Tenn.).

Evaluation of graphite and Hastelloy N surveillance samples removed from MSRE during the period is reported. Results of other work is summarized on radiation effects on commercial graphites, modification of Hastelloy N to improve radiation resistance, development of steel corrosion resistant to Bi, development of joining methods for Mo, and development of remote welding methods. (J.R.D.)

**17332** (ORNL-4480, pp 70-95) MECHANICAL PROPERTIES OF ALLOYS IN REACTOR ENVIRONMENTS AND DEVELOPMENT OF LMFBR CLADDING AND STRUCTURAL MATERIALS. (Oak Ridge National Lab., Tenn.).

From Fuels and Materials Development Program Quarterly Progress Report.

Type 316 stainless steel was irradiated in the annealed, 5, 10, and 20% prestrained conditions for about 4500 hr [$1.8 \times 10^{21}$ neutrons/cm$^2$ (thermal) and $1.4 \times 10^{21}$ neutrons/cm$^2$ (>1 MeV)] at 650°C. Postirradiation creep-rupture test results at 650°C indicate that, for these conditions, straining before irradiation has essentially no effect on the rupture life but significantly reduces the ductility. Initial results of creep-rupture tests at 600°C on specimens removed from the Experimental Breeder Reactor-II (EBR-II) safety-rod thimble indicate a decrease of both the ductility and rupture life. The dependence of the swelling induced by irradiation on fluence varies between $\Delta\rho/\rho \propto (\varphi t)^{0.84}$ and $\Delta\rho/\rho \propto (\varphi t)^{1.72}$ depending upon which data are accepted or rejected. The results of electron microscopy indicate that the void distributions are quite heterogeneous at low fluences. Measurement results indicate that the void concentrations decrease with increasing irradiation temperature at a constant fluence and increase with increasing fluence at a constant irradiation temperature. Measurement results have shown that a void grows to what appears to be a maximum or limiting size in a few times $10^{21}$ neutrons/cm$^2$; thereafter the growth rate decreases markedly. The role that carbide morphology and distribution play in the embrittlement of Incoloy 800 alloys is being evaluated. A discontinuous, agglomerated carbide formed along the grain boundary by means of a special heat treatment is stable at 500°C and results in improved creep ductility after long-term exposure. Irradiation of solution-annealed Incoloy 800 at 350°C enhances the aging response as evidenced during creep at 650°C. (auth)

**17333** RADIATION EFFECTS IN STRUCTURAL MATERIALS. Kangilaski, M. Reactor Mater.; 13: 21-38(Spring 1970).

A review is given on studies on radiation effects on nuclear structural materials, such as zirconium and zirconium alloys including Zircaloy-2. Irradiation testing results on all types of stainless steels are also reported. Tests on Inconel 102 and X-750 at elevated temperatures and the effects of helium on tensile properties are tabulated. Irradiation effects on A-350LF1 pressure vessel steel are also reported. The effects of radiation on miscellaneous materials and basic mechanisms of radiation damage in nonfuel materials are discussed. (55 references). (J.C.W.)

**17334** EFFECT OF NEUTRON IRRADIATION ON THE TEMPERATURE DEPENDENCE OF THE FLOW STRESS FOR NIOBIUM SINGLE CRYSTALS. Reed, R. E. (Oak Ridge National Lab., Tenn.); Guberman, H. D.; Armstrong, R. W. Phys. Status Solidi, 37: 647-55(1 Feb 1970).

Yield stress and strain-rate data were obtained in compression at various temperatures. Niobium single crystals were tested both in the irradiated and unirradiated condition. The neutron irradiation largely affected the athermal component of the flow stress; however, it also induced a smaller but measurable increase in the thermal component of stress. The data indicate that increasing solute content effects an athermal strengthening similar to that of neutron irradiation. (auth)

**17335** EFFECTS OF COLD HARDENING AND NEUTRON IRRADIATION ON X18H10T STEEL. Lapin, A. N.; Nikolaev, V. A.; Razov, I. A. (Central Scientific-Research Inst., Moscow). Fiz. Metal. Metalloved.; 28: 757-9(Oct 1969). (In Russian).

Mechanical properties of cold-hardened and neutron-irradiated X18H10T steel were studied using two specimens of steel irradiated with $6 \times 10^{20}$ N/cm$^2$ (neutrons with energies over 1 MeV) and untreated steel irradiated with $1.2 \times 10^{20}$ N/cm$^2$. Graphical data revealed that in specimens cold hardened up to 20% radioinduced yield was reduced with the increase of preliminary deformation. It was confirmed that the universally accepted point of view that radiation strengthening of steels of the same types is determined mainly by the level of irradiation. The specimens of cold-hardened steel showed that radiation increased the yield of the steel. The influence of irradiation and cold hardening was especially pronounced in diagrams of ductility. (R.V.J.)

**17336** RECENT STUDIES ON THE RADIATION EFFECT ON IRON AND STEEL. Igata, Naohiro (Tokyo Univ.). Nippon Kinzoku Gakkai Kaiho; 8: 764-76(Nov 1969). (In Japanese).

The radiation damage to iron and steel reactor pressure vessels is directly associated with irradiation embrittlement and is an important problem related to the nuclear reactor safety. Results of recent worldwide studies on the irradiation effects of iron and steel, especially ferritic steel, are reviewed. The formation of defects by irradiation, and their behavior, and the change in physical properties including electrical resistance, internal friction and magnetism are reviewed along with the change in strength characteristics including stress and strain, hardness, and impact strength accompanying the irradiation. An analysis of irradiation embrittlement and its mechanisms is included. (NSA of Japan)

**17337** GROWTH MECHANISM OF VOIDS IN FAST REACTOR IRRADIATED AUSTENITIC STAINLESS STEEL. Shiraishi, Kensuke (Japan Atomic Energy Research Inst., Tokai). J. Nucl. Sci. Technol. (Tokyo); 7: 111-12(Feb 1970).

A mechanism of radioinduced void growth in stainless steel is proposed and discussed. Results of calculations on void radius indicate that those occurring in steel irradiated in fast reactors are much larger than in specimens irradiated in ETR, and that the radius of voids observable by electron microscope at a specified fast neutron flux is affected by the size of the void nucleus. (J.R.D.)

**17338** NEUTRON DAMAGE IN MOLYBDENUM IRRADIATED AT HIGH TEMPERATURES. Rau, R. C.; Secco d'Aragon, F.; Ladd, R. L. (General Electric Co., Cincinnati). Contract AT-(40-1)-2847. Phil. Mag.; 21: 441-52(Mar 1970).

Transmission electron microscopy has been used to characterize the microstructure of polycrystalline molybdenum irradiated at elevated temperatures (>0.3 $T_m$). Irradiation at 700°C produces dislocation loops within the grains and denuded zones along grain boundaries, while irradiation at 1000°C results in generally loop-free grains which occasionally contain bands of loops and dislocation debris parallel to grain boundaries. Diffraction contrast analyses show that most of the loops are interstitial edge type, having $a/2\langle 111\rangle$ Burgers vectors, but that a few $a\langle 100\rangle$ loops are also present. Irradiation at these temperatures also produces small voids which are interpreted as representing aggregates of radiation-induced vacancies. (auth) (UK)

**17339** CONTAMINATION OF SURFACES DURING HIGH-ENERGY ELECTRON IRRADIATION. Hart, R. K.; Kassner, T. F.; Maurin, J. K. (Argonne National Lab., Ill.). Phil. Mag.; 21: 453-68(Mar 1970).

Specimen contamination during electron-optical examination has been studied using "holey" carbon-film specimens in a modified electron microscope. The composition of the residual gas atmosphere was determined by mass-spectrometric analysis. The gas pressure in the vicinity of the specimen was reduced to between $10^{-5}$ and $10^{-6}$ torr by differential pumping. The functional dependence of contamination rate on specimen temperature was also investigated between −85 and +200°C. Both the source of carbon-bearing gas molecules and the growth rate of carbon film caused by the interaction of electrons with adsorbed carbonaceous species were investigated. The results indicate that molecules contributing to the observed rates of film growth originate not only from the specimen surrounds, but also from the region along the electron-beam path, possibly from as far away as the electron gun. However, with both these sources included, calculations showed that the supply of contaminating gas molecules was barely sufficient to explain the observed contamination rates. An additional contribution caused by surface migration of adsorbed gas to the area irradiated by the electron beam was also considered. This surface-diffusion contribution has been included in an expression that describes the growth rate of the surface contamination layer. A numerical method was employed to best fit the theory to the ex-

perimental data. From electron-transmission measurements on growing contaminant film, a value of $(9.89 \pm 1.27) \times 10^4$ cm$^{-1}$ was obtained for the scattering cross section of carbon for 100 kV electrons. (auth) (UK)

**17340** INTERSTITIAL DOUBLE LOOPS IN PROTON-IRRADIATED COPPER. Tunstall, W. J. (Chalmers Univ. of Tech., Goteborg); Eriksson, L.; Mazey, D. J. Phil. Mag.; 21: 617-22 (Mar 1970).

Double stacking-fault loops in proton-irradiated copper are identified as being of interstitial type by electron microscope contrast analysis. The experimental method is justified by theoretical contrast calculations for the diffraction conditions concerned using the two-beam dynamical theory of electron diffraction. The relevance of the result to a recent theory of double loop nucleation (Bacon and Bullough 1968) is discussed. (auth) (UK)

# Ceramics and Cermets

*Refer also to abstracts 17189, 17190–17192, 17195, 17331, and 18587.*

## Corrosion and Erosion

*Refer also to abstract 16733.*

**17341** GRAPHITE OXIDATION: THE MOBILE SURFACE-OXIDE INTERMEDIATE. Marsh, H. (Univ. of Newcastle-Upon-Tyne, Eng.); O'Hair, T. C. Carbon; 7: 702-3(Dec 1969).

Purified graphite crystals, oxidised with molecular $O_2$ at 890°C to develop hexagonal pits, were further oxidised with atomic $O_2$ for 2 to 4 hr at 200°C and the surfaces examined by optical microsopy. There was general removal of C atoms from the basal plane without any widening of the horizontal pits. Surface steps, originally present, persisted throughout the process. The results are considered in relation to previous studies on the role of surface oxide during the oxidation process. (UK)

**17342** SURFACE WEAR STUDIES AND THEIR USE FOR INVESTIGATIONS ON TUNGSTEN CARBIDE LAYERS. Horn, Jochen. Wiss. Z. Tech. Hochsch. Karl-Marx-Stadt; 10: 283-9(1968). (In German).

Techniques for studying surfaces are briefly reviewed and the results of electron-microscope and electron-beam-microsonde studies of WC surfaces undergoing wear are reported. With sintered carbide layers which possess a hard metal structure and in which diffusion occurs into the substrate layer, the wear resistance is increased. (Metals Abstr.)

## Preparation and Fabrication

*Refer also to abstracts 16547, 16640, 16748, 16923, 17224, 17233, 17237, and 18724–18726.*

**17343** (ORNL–4480, pp 36-57) DEVELOPMENT OF HIGH-PERFORMANCE LMFBR FUELS. (Oak Ridge National Lab., Tenn.).

From Fuels and Materials Development Program Quarterly Progress Report.

A satisfactory process was developed for hot pressing physically mixed (U,Pu)N pellets to 98% of theoretical density. Production of pellets for irradiation tests in Na-bonded capsules is under way. Kinetic studies showed that vacuum conversion of $UV_2$–C gels to UCN is much more rapid than reaction in a fluidized bed in inert gas. An apparatus has been readied for vacuum conversion of $(U,Pu)O_2$–C gels to mixed carbonitrides. Studies of the ternary compound $UVC_2$ showed that it is unstable above 1900 ± 100°C. At 1800°K the free energy of formation of $UVC_2$ is −47.8 ± 0.3 kcal/mole. (auth)

**17344** (ORNL–4480, pp 129-46) DEVELOPMENT OF FAST-REACTOR NEUTRON-ABSORBER MATERIALS. (Oak Ridge National Lab., Tenn.).

From Fuels and Materials Development Program Quarterly Progress Report.

Studies directed toward obtaining a better understanding of irradiation behavior of absorbers to be used in fast reactors are reported. Current interest is directed toward well-characterized $B_4C$. Commercial grades of $B_4C$ powder where found to consist of mixtures of particles that vary in B:C ratio, internal porosity, and surface graphite. The electron scanning microscope was used to show surface morphology of the powders. Specialized techniques of x-ray diffraction and metallography were developed to characterize these powders. Very fine polyhedral voids are found in the material depending upon the composition. Some metastable phases were observed but as yet are unidentified. Irradiation tests were planned, and materials for these tests are being prepared. (auth)

**17345** (ORNL–4480, pp 213-44) DEVELOPMENT OF FUEL ELEMENT FABRICATION. (Oak Ridge National Lab., Tenn.).

From Fuels and Materials Development Program Quarterly Progress Report.

A proposed technique for reducing losses caused by blistering is to provide more porosity in the filler sections by adding powdered $ZrO_2$ to the Al. Such plates were successfully fabricated, and the number of blisters was reduced. It was found that plates fabricated from loose-fitting powder cores do not blister, while others fabricated similarly from dummy wrought cores do blister. With the powder cores, misfits in size as large as 5.3% were fabricated without blistering, while 1% misfit produced blistering in wrought cores. In studies of the effects of plate cleaning on bonding, as measured by interfacial grain growth, it was found that for ranges investigated neither the concentration nor the temperature are sensitive variables in the Oakite 160-$HNO_3$ process. The amount of grain growth was, however, reduced by 10% by excessive use of the solution. Nickel present on the surface of the Al seriously interferes with this cleaning technique. Studies of the mechanism by which fuel plates deform during fabrication continued. It was found that the first two rolling passes do not densify the powder cores very much, but the next three do. Reduction of dogboning by using low-density cores is being studied. The density of pressed cores was varied by changing the compacting pressure. Cores showed comparable densities whether the fuel was $U_3O_8$ or $UAl_x$. In the degassing step, the expansion of the oxide cores was not dependent on temperature while that of the $UAl_x$ cores was. The effects of fuel particle size and surface area on fuel homogeneity was measured using a scanner. Values of surface area and toluene density were measured for the various size fractions of both high-fired and burned $U_3O_8$ and were found to be independent of the particle size. The primary source of error in the use of radiography and densitometry in determining fuel homogeneity is the ±0.02 inaccuracy due to limitations of the densitometer for measuring film density. This can cause an error of ±5% in homogeneity data. A new task was incorporated on refractory-metal dispersion fuel elements. Samples of irradiated W–Re–Mo clad W–$UO_2$ and W–$UO_2$–$ThO_2$ specimens are being examined. As the result of a fission break, the samples were removed from the Oak Ridge Research Reactor after achieving a burnup of $1.5 \times 10^{20}$ of a scheduled $2 \times 10^{20}$ fission/cm$^3$. On examination, it was determined that the fission gas was released from a pinhole leak in a single sample. Dimensional measurements show that all samples swelled. (auth)

**17346** NUCLEAR FUEL. (to Societe Belge Pour l'Industrie Nucleaire). British Patent 1,182,080. 25 Feb 1970. Priority date 12 Sep 1968, Belgium.

A method of fabricating fuel pellets from ceramic powders by agglomeration, granulation, pelletizing, and sintering is described. A thermal treatment at 600 to 1000°C is carried out after the agglomeration step and before pelletization to reduce the sinterability of the ceramic powder. (J.R.D.)

**17347** ENTHALPY OF FORMATION OF URANIUM SESQUICARBIDE. Huber, Elmer J. Jr.; Holley, Charles E. Jr.; Witteman, W. G. (Los Alamos Scientific Lab., N. Mex.). J. Chem. Thermodyn.; 1: 579-87(Nov 1969).

The enthalpy of formation of uranium sesquicarbide was determined by means of oxygen bomb calorimetry and found to be $\Delta H_f^\circ$ $(U_2C_3, 298.15°K) = -(43.4 \pm 1.8)$ kcal mol$^{-1}$. (auth) (UK)

**17348** PREPARATION OF SINTERED $UO_2$ FOR TRANSMISSION ELECTRON MICROSCOPY. Morel, P. A. (Atomic Energy of Canada Ltd., Chalk River, Ont.). Metallography; 2: 399-402(Dec 1969).

Experience gained in thinning of $UO_2$ to electron transparency is the basis for an electropolishing technique by which clean thin foils can be produced semiautomatically. The prepared specimens are small enough to be placed directly into an electron microscope holder. Techniques used in preparing such samples are described. (J.R.D.)

**17349** FABRICATION METHOD FOR NUCLEAR FUEL. (to Societe Belge Pour l'Industrie Nucleaire). British Patent 1,182,039. 25 Feb 1970. Priority date 23 Aug 1967, Belgium.

A method of fabricating fuel for gas-cooled reactors is described. The fuel elements produced by this method are composed of kernels previously coated with at least one dense impermeable layer and an outer layer of pyrolytic carbon. Fissile, fertile, and/

or poison particles may be incorporated in the elements. The outer coating serves as a bond to hold particles together. (J.R.D.)

17350 FUELS FOR NUCLEAR POWER PLANTS. Tuohy, T. Ing. Nucl., 10: No. 2, 3-5(Mar.-Apr. 1969). (In Italian).

The technological experiences in Great Britain in the manufacture of fuel elements, the conversion of the hexafluoride, reprocessing of the irradiated fuels, fabrication of the plutonium elements, and economy of the operation are briefly summarized. (J.S.R.)

17351 REVIEW OF METHODS OF BONDING OR MAKING ELECTRICAL CONTACTS TO DIAMOND. Seal, Michael. Engelhard Ind., Tech. Bull.; 10: No. 1, 10-15(Jun 1969).

Bonding of diamonds is best effected by solders which are alloys from group 4b or 5b of the periodic table (Ti, Zr, V, Nb, Ta) with a suitable solvent, such as Au or Cu–Ag eutectic. Reviews the practical and theoretical work supporting this conclusion. Contacts welded to a diamond block with an Au–Ta alloy illustrate successful experiments. (Metals Abstr.)

17352 NEW ELECTRIC PROCESS JOINS GLASS TO METALS. Weld. Eng.; 54: No. 6, 48-9(Jun 1969).

Glass is bonded to metal by a new process in which the materials are heated to 350 to 500°C and a dc electrical voltage is applied across the glass-metal sandwich with positive voltage applied to the metal. The glass and metal must have a reasonable match of their expansion coefficients and be relatively flat. Fracture strengths of 2000 to 3000 psi were obtained and bonds survived a cycle of −55 to 125°C. Silicon, Ge, GaAs, Ta, Carpenter 49, Niromet 44 and Kovar are some of the materials which were bonded. Iron, Ni, Cr, B, Al, Mg, Ti and Be were bonded to glass as films and foils. (Metals Abstr.)

17353 HIGH-PRESSURE, HIGH-TEMPERATURE SYNTHESES OF SELECTED LANTHANIDE–TELLURIUM COMPOUNDS. Cannon, John Francis. Provo, Utah; Brigham Young Univ. (1969). 54p.

Thesis.

High pressure, high temperature technics were employed to successfully synthesize $HoTe_{1.7}$, $ErTe_{1.7}$, $TmTe_{1.7}$, $LuTe_{1.7}$, $YTe_{1.7}$, and $LuTe_3$. The pressure-temperature regions in which synthesis of each compound is successful were determined. Even with pressures to 100 kbars and temperatures to 1200°C, attempts to prepare $ScTe_{1.7}$ and $ScTe_3$ were unsuccessful. X-ray studies of these new compounds confirmed that they are extensions of the $LTe_{2-x}$ ($0 \leq x \leq 0.3$) and $LTe_3$ series (L = lanthanide) previously reported through Dy for $LTe_{2-x}$ and through Tm for $LTe_3$. The lattice parameters are reported and compared (versus lanthanide ionic radius) with those of the previously known analogs. (Diss. Abstr. Int., B)

17354 REVIEW OF THE ITALIAN INDUSTRIAL ACTIVITY IN THE FIELD OF FUEL ELEMENT FABRICATION. pp 129-35 of Utilizzazione del Combustibile Nucleare. Roma; Comitato Nazionale Energia Nucleare (1969). (In Italian).

From 10th International Nuclear Energy Conference, Milan, Italy. See CONF-681219.

The purpose for which Combustibili Nucleari S.p.A. was established and the plant for the fabrication of Latina-type fuel elements are discussed. The Company's plant will assemble natural metallic uranium fuel elements from machined uranium rods and finished cans and cladding components. The activities already in progress, and those planned for the near future, afford good hopes for the future of Combustibili Nucleari. The guidelines are mentioned for the nuclear sector recently approved by Italy's National Economic Planning Committee, reserving for the National Hydrocarbons Agency (ENI) a pre-eminent role in all activities concerning the entire nuclear fuel cycle, the exploration for ores, the fabrication of fuels and the reprocessing of irradiated fuels. (auth)

## *Properties Evaluations*

*Refer also to abstracts 16503, 16787, 17235, 17265, 17267, 17274, 17343, and 18668.*

17355 (BNWL-tr-44) BORON CARBIDE: PRODUCTION, PROPERTIES, AND APPLICATIONS. Lipp, Alfred. Translated for Battelle-Northwest, Richland, Wash., from Tech. Rundsch.; Nos. 14, 28, 33(1965); No. 7, 3-47(1966). 101p. Dep. CFSTI.

A review of information on production, properties, and uses of boron carbide is presented along with information on crystal structure. Phase diagrams are also included. (J.R.D.)

17356 (INR-1125) INVESTIGATION OF FISSION PRODUCT RELEASE FROM CARBON-COATED FUEL PARTICLES. Jozefowicz, Krystyna (Institute of Nuclear Research, Warsaw (Poland)). 1969. 19p. (In Polish). Dep. CFSTI (U. S. Sales Only).

The mechanism of fission product release from irradiated grain fuels at various temperatures is described. Various methods used for fission product release measurement are reviewed. Two methods are described to examine $UO_2$ or $UC_2$-type grain fuels coated with pyrolytic carbon. The first method, based on the measurement of fission iodine release from irradiated fuel samples into water at a temperature less than 100°C, is suitable for rough estimation of fuel coating performance. The second method, a high temperature one, is based on the measurement of fission xenon release from irradiated fuel samples during heating at a 1100°C. Fission gas escaping from the fuel is swept off with an argon stream and absorbed in an active charcoal trap. Gamma activity of the fission gas is measured using the scintillation counter. The high temperature method has been used to measure fission gas release from 12 samples of $UC_2^*$ pyrolytic C-coated type fuels, post-irradiation heated at temperature 1070°C. The results are compared with fission gas release from uncoated $UC_2$ grains. (auth)

17357 (IS-2100, Sect. C and ME) CERAMIC AND MECHANICAL ENGINEERING DIVISION. Hansen, Robert S.; Wilder, D. R.; Fisher, R. W.; Hunter, O. (Ames Lab., Iowa). 13p.

Research results are presented on diffusion and structure of rare earth oxides, emittance of uranium oxides, elastic properties of refractory borides, thermal diffusivity of ceramic materials, corrosion of Inconel by sodium, corrosion of uranium and chromium by liquid metals, and mass transport in refractory oxides. (J.R.D.)

17358 (KFK-tr-306) INVESTIGATION OF THE HOT HARDNESS OF ZIRCONIUM CARBIDE. Evstyukhin, N. A.; Shchavelin, V. M. Translated by Rosemarie Corssen (Kernforschungszentrum, Karlsruhe, Ger.), from Met. Metalloved. Chist. Metal., Sb. Nauch. Rabot; No. 6, 101-7(1967). 9p. (In German). Dep. CFSTI (U. S. Sales Only).

An abstract of this paper, prepared from the original language, appeared as NSA 23: 8312.

17359 (RT/PROT-(69)12) EFFICIENCY OF ACTIVATED CHARCOAL FOR THE REMOVAL OF METHYL IODIDE IN HIGH HUMIDITY. Ferreli, A.; Bocola, W.; Belardi, G. (Comitato Nazionale per l'Energia Nucleare, Rome (Italy)). 18 Mar 1969. 44p. (In Italian). Dep. CFSTI (U. S. Sales Only).

A study of the efficiency of impregnated charcoal for the removal of methyl iodide from high humidity environments is reported. The interaction of various parameters on the adsorption phenomena was investigated. The experimental conditions and parameters considered are itemized. The results are diagrammed and discussed. A graphical correlation between the penetration and operative parameters is proposed which will facilitate the preliminary design of potassium iodide-impregnated charcoal beds for specified operative conditions. (auth)

17360 (WARD-4135-1) OXIDE FUEL ELEMENT DEVELOPMENT. Quarterly Progress Report for Period Ending September 30, 1969. (Westinghouse Electric Corp., Madison, Pa. Advanced Reactors Div.). Nov 1969. Contract AT(30-1)-4135. 106p. Dep. CFSTI.

Additional data on swelling of solution treated 316 stainless steel at relatively high temperatures were obtained. Using preliminary temperature calculations, a revised swelling correlation for solution-treated material was developed. Improvements in the OLYMPUS code are continuing. A fuel-cladding gap model is now being included in the OLYMPUS code calculations. An analysis of the sensitivity of the CYGRO code to material properties and performance models was initiated to provide a basis for selecting the critical areas in the code which require modifications. Parametric studies covering a range of linear powers and three fuel swelling models were conducted, using the present form of the code. Correlation of secondary creep rate data for 316 cold-worked and solution-treated stainless steels was completed. Irradiation-induced creep analysis was continued, and preliminary correlations were established. A fuel thermal conductivity relationship was developed to improve temperature profile calculations required for performance analyses. The thermal, nuclear, and mechanical designs, including all drawings and design analyses, were completed for the 19-capsule subassembly WSA-2. Fabrication of the pins is in progress. Safety analyses are nearly complete and the report in preparation. Design, design analyses, and drawings for all pins except the four pins containing axial spacers are complete for subassembly WSA-1 (irradiation of this subassembly will follow WSA-2). Analysis of the spacer pins is nearly

complete. Fuel for this assembly has also been received. Results of fuel pin performance analysis using the OLYMPUS code indicated that the forced strains may exceed 1% for the previously selected pin parameters. Consequently, the maximum smear density was reduced from 93% to 90% TD. Preparation of pin drawings was initiated. Detailed subchannel analysis of the subassembly was conducted using the COBRA code. Corner radii of the grid liners were increased by 13 mils to reduce the temperature gradient across the corner fuel rods. Pin bowing analyses using the FATBO-2 code and the method of Rapier were in agreement, and showed that axial grid spacings of 5.4 inches or less are satisfactory. Analysis is contuining to establish the pin-grid gap. Welding development continued with resistance spot welding as the reference method for grid fabrication and TIG spot welding for attaching grid support straps to the inner can. A parametric study of resistance spot welding parameters to determine conditions yielding maximum strength with minimum grid distortion was completed. Optimum conditions for TIG spot welding of grid support straps were established. Design and drawings for the grid strap forming tools were completed and a purchase order was placed. Fabrication is proceeding on schedule. Design and drawings of tooling for two grid strap cut-off tools and for shearing and forming grid support straps were completed. Drawings of tooling for forming the liners were completed, except for length specifications. Fabrication of $UO_2$ insulator pellets for the 19-capsule subassemblies was completed. Milling trials on $UO_2$ were conducted to determine preliminary parameters for $PuO_2-UO_2$ mixing. Initial tests indicate that $Al_2O_3$ grinding media is preferred to WC. Initial pressing and sintering trials with $UO_2$ were conducted to determine the range of parameters for preparing high density $PuO_2-UO_2$ pellets and for preparing the $UO_2$ insulator pellets for the grid-subassembly test. All glove boxes and ventilation equipment for the Plutonium Oxide Laboratory were installed. Preliminary $UO_2$ work is being conducted in these glove boxes. Development of analytical and characterization techniques for $PuO_2-UO_2$ and $UO_2$ powder and pellets is in progress. Present emphasis is on O/M ratio determinations, immersion density, and metallographic methods. Detailed analyses and characterization of $UO_2$ powders milled by different processes were conducted to guide process development. Tests of the $PuO_2-UO_2$ pellets for 19-pin subassembly experiments were initiated. Mock-up fuel rods and capsules, employing $PuO_2-UO_2$ pellets received from the vendor for the 19-pin tests, are being fabricated. Dimensioning and density calculations of the vendor fabricated 93% enriched $PuO_2-UO_2$ pellets were completed. A computer program was prepared to calculate densities and standard deviations for the 800 pellets received. Pellets closest to the mean are being selected for loading into the fuel rods. Density determinations for the 43% and 65% enriched pellets are in progress. (auth)

**17361** VAPORIZATION OF PLUTONIUM MONONITRIDE. Marcon, Jean Pierre; Poitreau, Jean (CEN, Fontenay-aux-Roses, France). J. Inorg. Nucl. Chem.; 32: 463-7(Feb 1970). (In French).

The Knudsen method was employed to measure the vapor pressure of plutonium mononitride. It was confirmed that the dissociation of PuN is given by the following reaction: $PuN(s) \rightarrow Pu(l) + \frac{1}{2}N_2(g)$. The enthalpy of formation at 298°K ($\Delta H = -72.8$ kcal) obtained from this study agreed very well with the other thermodynamic measurements for this compound. (auth) (UK)

**17362** OXYGEN DIFFUSION IN MONOCLINIC ZIRCONIA. Poulton, D. J.; Smeltzer, W. W. (McMaster Univ., Hamilton, Ont.). J. Electrochem. Soc.; 117: 378-81(Mar 1970).

Oxygen-18 enriched oxygen and carbon dioxide-carbon monoxide atmospheres have been used in the determination of the oxygen self-diffusion coefficient in monoclinic zirconia at 990°C. Oxygen exchange measurements were made on zirconia spheres in the average size ranges of 90 and 126μ. The diffusion coefficient was found to be independent of both oxygen partial pressure over the range 1 to $10^{-19}$ atm and sphere size. The value of the diffusion constant has been used with previously determined electrical conductivity data to verify postulates of a defect model involving oxygen ion vacancies for monoclinic zirconia. (auth)

**17363** HEATS OF COMBUSTION OF SILICON CARBIDE AND TUNGSTEN MONOCARBIDE. Yudin, B. F.; Markholiya, T. P. Zh. Prikl. Khim.; 42: 2587-9(Nov 1969). (In Russian).

Work performed with tungsten monocarbide showed that the oxidation product $WO_3$ melts at 1453°C, i.e., in the process of combustion of WC at 1700°C, $WO_3$ is melted. The proposed method for the measurement of heats of combustion for carbides can also be applied to the measurement of the heats of combustion of viscous and nonviscous materials, of which $SiO_2$ and $WO_3$ are respective examples. (tr-auth)

**17364** STORED ENERGY IN CREEP DEFORMED GRAPHITE. Green, W. V.; Zukas, E. G. (Los Alamos Scientific Lab., N. Mex.). Nature (London); 225: 628-9(14 Feb 1970).

Graphite that has been strained in tensile creep releases a large amount of stored energy when the creep stress is reduced, and the large amount of negative creep (actual shrinkage of a specimen while still under an appreciable applied tensile force) that takes place after a stress reduction is shown graphically. In a series of tests on ZTA graphite the largest measured amount of energy released was $1.1 \times 10^6$ ergs/cm$^3$ (0.17 cal/g atom); this occured when a specimen was strained almost to fracture (20% elongation) at 3,200 lb/in.$^2$, at which point the applied stress was reduced to 1,600 lb/in.$^2$ The negative creep strain after the load reduction was 1.2%. After a time the negative creep ended, but additional negative creep, four times greater than that already measured, occurred after complete removal of the applied stress. Calculations were made from the appropriate surface and line energies of the crack area or dislocation line length per unit volumes, which if annihilated during recovery, would release this amount of energy. Annihilation of $1 \times 10^{10}$ to $5 \times 10^{10}$ cm/cm$^3$ length of dislocation would account for the observed release of stored energy. From the calculations either form of imperfection could account for the observed energy release. Either surface area of bending deformation could dominate in the storage of energy, and at present it is not possible to favour one mechanism over the other. It is pointed out that graphite can sustain higher stresses than a metal and can therefore store more energy. The fact that graphite lacks slip systems capable of plastically deforming any given crystal along the c-axis must in some way be responsible for the large build-up of stored energy. (UK)

**17365** POISSON'S RATIO OF PYROLYTIC CARBON. Price, R. J.; Kaae, J. L. (Gulf General Atomic Inc., San Diego, Calif.). Carbon; 7: 706-8(Dec 1969).

Poisson's ratio was determined for a high-temperature and a low-temperature isotropic fluidised-bed pyrolytic carbon, and compared with values for oriented massive pyrolytic carbon. The material was stressed parallel to the deposit plane. Values depended upon the degree of orientation. Negative values for the oriented pyrocarbons are explained. (UK)

**17366** NONFUELED REFRACTORIES. Niesz, D. E. Reactor Mater.; 13: 39-41(Spring 1970).

Nonfuel refractories were studied for possible nuclear applications. An investigation of the plastic properties of WC subjected specimens to precise micrographic observations during tests for indentation, impact, and friction. The recrystallization and sintering of WC at high temperatures, the morphology of WC crystals, and the growth of grains at high temperature were studied. The mechanical behavior of pure $VC_{0.85}$ doped with boron was studied at 1000 to 1700°C. The temperature dependence of the external friction of pairs of NbC and TaC from room temperature to 1800°C was investigated. Creep behavior and the effects of multiaxial stresses on fracture strength and specimen geometry and structure on the impact resistance of silicon carbide were studied. In cermets containing NbC and HfC, it was found that NbC could be replaced by the expensive TaC. The mechanical properties of zirconium dioxide and WC–Co are discussed in relation to structure. (J.C.W.)

**17367** THE THERMAL CONDUCTIVITY OF CERMETS AND ITS MEASUREMENT BY THE RADIAL HEAT FLOW METHOD IN $La_2O_3$–W. Ondracek, G.; Schulz, B.; Thuemmler, F. (Kernforschungszentrum, Karlsruhe, Ger.). High Temp. - High Pressures; 1: 439-47(1969). (In German).

The difficulties in measuring the thermal conductivity of cermets, arising from their composite structure, are discussed. Measurements are reported on the system $La_2O_3-W$, using a special arrangement of the radial heat flow method. The reproducibility and temperature dependence of the results are assessed. The variation of thermal conductivity with concentration of the metallic phase is discussed on the basis of theoretical considerations. The calculated curves are compared with the experimental results as well as with values reported in the literature, and reasons for the observed deviations are suggested. (auth)

**17368** DIFFUSION OF THE COMPONENTS OF A [CARBIDE] TOOL ALLOY INTO NICKEL CREEP RESISTANT ALLOYS. Saamishvili, A. D. Tr. Gruz. Politekh. Inst.; No. 7, 199-205 (1968). (In Russian).

Measurements were made of the parameters of diffusion of the sintered carbide tool alloys VK8 (WC 92, Co 8) and T15K6 (WC 79, Co 6, TiC 15%) into Ni and Ni-base alloys. Since, during cutting, the time of contact of the turnings with the cutting tool is insufficient to obtain a diffusion layer of a thickness that can be

resolved by an optical microscope, the cutting process was simulated. Local chemical analysis of the diffusion zone showed that only W diffused from the tool alloy into the layers more remote from the cutting tool. Calculations of the diffusion layer thickness were made and the W diffusion parameters for the different materials are given in a table. The diffusion of the W from a tool alloy into Ni is slower than that into Ni-base alloys. The diffusion coefficient for W into Ni in heat-resistant alloys is higher for the TK-type alloys than that for the VK-type alloys. (Referativnyi Zh.)

**17369** NUCLEAR FUEL WARRANTIES: A 1970 APPRAISAL. Ginder, J. R.; Goellner, D. A. (Combustion Engineering, Inc., Windsor, Conn.). Elec. Light Power (Boston); 48: No. 2, 75-7 (Feb 1970).

The utility that wants a warranty on energy output will find definite advantages to a warranty based on core energy output per cycle, with warranty compliance determined from heat balance calculations alone. This warranty would omit any subsequent breakdown of the total energy among various groups of assemblies. Further, the desire among utilities for flexibility in fueling their reactors can be served best by eliminating the energy warranty. The absence of an energy warranty plus close cooperation between fuel supplier and utility should ensure a fuel management plan that will satisfy any utility's requirements. (auth)

**17370** AXIAL THERMAL EXPANISON OF $ZrO_2$ AND $HfO_2$ IN THE RANGE ROOM TEMPERATURE TO 1400°C. Patil, R. N.; Subbarao, E. C. (Indian Inst. of Tech., Kanpur). J. Appl. Crystallogr.; 2: 281-8(1969).

The axial thermal expansion of monoclinic and tetragonal $ZrO_2$ and of monoclinic $HfO_2$ was studied over the temperature range from room temperature to 1400°C. The linear thermal expansion coefficients were calculated. Some aspects of the present study, such as anisotropy of thermal expansion and a pretransformation vibrational anomaly, are discussed briefly. (auth)

**17371** SELECTIVE ADSORPTION AT GRAPHITE/HYDROCARBON INTERFACES. Groszek, A. J. (British Petroleum Co. Ltd., Middlesex, Eng.). Proc. Roy. Soc. (London), Ser A; 314: 473-98(27 Jan 1970).

A study was made of adsorption of n-dotriacontane and n-butanol dissolved in n-heptane onto graphitized carbon black and various ground graphites having surface areas ranging from 5 to 700 $m^2 g^{-1}$. It was established that the adsorption of n-dotriacontane by the graphites is confined entirely to the basal planes of graphite crystals. This is attributed to a remarkable fit between the hydrogen atoms attached to one side of the zig-zag carbon chain in the normal paraffins and the centers of hexagons formed by the carbon atoms in the basal planes of the substrate. The longer the chain the more contacts it can form with the graphite surface and the more strongly it is adsorbed. More detailed studies of the adsorption of n-paraffins on ground graphites showed that they form close-packed monolayers of horizontally disposed molecules on the basal planes. There is little further adsorption after the monolayers are complete. The heat of adsorption per molecule increased uniformly with the chain length reaching very high values for the normal paraffins having more than 30 carbon atoms. The formation of the close-packed layers has been used for the measurement of the proportion of basal plane surface in different types of graphites. n-Butyl alcohol also formed closely packed monolayers, but on the polar sites of graphites, which can be used for the estimation of their area. The basal plane and polar sites act independently in adsorption and their relative proportions characterize the adsorptive properties of graphites. Examination of graphite ground in n-heptane, which consists of plates of average area of several square micrometers and average thickness of 5 nm, showed that its surface consists predominantly of basal planes having a high adsorptive capacity for n-paraffins. (auth) (UK)

**17372** STUDY OF THE SYSTEMS FORMED BY ZIRCONIA WITH CALCIA AND WITH STRONTIUM OXIDE. Traverse, J.-P.; Foex, M. (CNRS, Odeillo, France). High Temp. - High Pressures; 1: 409-27(1969). (In French).

A 2 kW solar furnace was used to obtain solidification curves for the systems $ZrO_2$–SrO and $ZrO_2$–CaO and to establish the melting points of CaO (2900°C), $CaZrO_3$ (2370°C), SrO (2660°C), $SrZrO_3$ (2750°C) as well as the various eutectics. The thermal effects were checked by x-ray diffraction analysis and, with the exception of one effect in the $SrZrO_3$–SrO system, found to correspond to phase changes. The limits of existence of cubic solutions of $ZrO_2$ with CaO and with SrO at high temperatures are reported. The compounds $CaZrO_3$ and $SrZrO_3$ are polymorphic; at high temperatures they both exhibit perovskite cubic structure. In the $SrZrO_3$–SrO system two other compounds have been established: $Sr_3Zr_2O_7$ and $Sr_2ZrO_4$, both of tetragonal form. (auth) (UK)

**17373** HIGH-TEMPERATURE THERMAL EXPANSION OF $UO_2$ AND $ThO_2$. Hoch, M.; Momin, A. C. (Univ. of Cincinnati). High Temp. - High Pressures; 1: 401-7(1969).

The thermal expansion of uranium dioxide and thorium dioxide has been measured between 20 and 2100°C using high temperature x-ray diffraction techniques. The thermal expansion of $UO_2$ and $ThO_2$ as measured by x-ray diffraction is identical to that obtained by bulk expansion measurements. Because of this, and because the specific heat of $UO_2$ shows a rapid increase above 1700°C indicating a disorder, it is concluded that the major structural defect is a Frenkel type disorder. This probably involves the oxygen atom moving from the tetrahedral into an empty octahedral position. (auth) (UK)

**17374** MELTING POINT OF BERYLLIUM FLUORIDE. Belousov, V. I.; Sidorov, L. N. (Moscow State Univ.). Zh. Fiz. Khim.; 44: 254-5(Jan 1970). (In Russian).

Published data are presented which show the melting point for $BeF_2$ at 542 ± 3°C and 795 to 803°C. Experimental data obtained indicated the melting point for $BeF_2$ at 800 ± 5°C. (R.V.J.)

**17375** THE MICROHARDNESS OF β–VANADIUM HYDRIDE BETWEEN 77° and 300°K. Westlake, D. G.; Ockers, S. T. (Argonne National Lab., Ill.). J. Less-Common Metals; 20: 207-14(1970).

The microhardness has been measured, between 77 and 300°K, of polycrystalline β-vanadium hydride specimens with hydrogen concentrations of from 33.8 to 43.7 at. % H. Photomicrographs of the indentations were made at temperature, none of which showed any indication of brittle behavior. The hardness of V–33.8 at. % H at room temperature was about 215 $kg/mm^2$ compared with about 65 $kg/mm^2$ for hydrogen-free vanadium. Increasing the hydrogen concentration to 41.2 at. % caused a softening. The hardnesses of the hydrides rose much more sharply with decreasing temperature than did that of the metal at temperatures below 200°K. (auth)

**17376** STRUCTURE AND PROPERTIES OF PYROLYTIC SILICON CARBIDE. Price, R. J. (Gulf General Atomic, Inc., San Diego, Calif.). Am. Ceram. Soc. Bull.; 48: 859-62(Sep 1969).

Pyrolytic silicon carbide offers important advantages for coating spherical particles of oxide or carbide nuclear fuels, as such coatings demonstrate a low neutron absorption cross section, good retention of fission products, high mechanical strength and thermal conductivity, and good stability under neutron irradiation. A study was made of the structure and physical properties of pyrolytic β-silicon carbide deposits from methyltrichlorosilane-hydrogen mixtures in a fluidized bed at 1200 to 1800°C. Internal strains, measured from x-ray line broadening, decreased with increasing deposition temperature. The (111) planes tended to lie parallel to the deposition surface. The degree of preferred orientation was fairly insensitive to deposition temperature below 1700°C, but increased sharply between 1700 and 1800°C. Among specimens prepared at 1400°C, the preferred orientation was higher for higher silane input rates. The room temperature modulus of rupture and Young's modulus, for diamond lapped specimens measured in three-point bending, were $135 \times 10^3$ psi and $62 \times 10^6$ psi, respectively. The thermal conductivity of 1400°C material was 0.07 to 0.15 cal/cm-°C sec at room temperature and decreased by 40% over the interval 22 to 600°C. The mean thermal expansion coefficient between 22 and 1000°C was $4.9 \times 10^{-6}$ °$C^{-1}$ and was insensitive to deposition conditions. (BBB)

**17377** THERMAL BEHAVIOR OF EUROPIUM OXIDES. Ignat'eva, N. I.; Bamburov, V. G. (Inst of Chemistry, Moscow). Izv. Akad. Nauk SSSR, Neorg. Mater.; 6: 154-5(Jan 1970). (In Russian).

Thermal studies were made of the lower europium oxides in the air. X-ray analyses showed that oxidation products of EuO at 310°C are EuO and $Eu_3O_4$; at 310 to 420°C EuO, $Eu_3O_4$, and B–$Eu_2O_3$; and at 420 to 710°C $Eu_3O_4$ and B–$Eu_2O_3$. Sintering of the lower europium oxides at 710°C resulted in a single-phase monoclynic specimen of $Eu_2O_3$ following the conversion of EuO → $Eu_3O_4$ → B $Eu_2O_3$. (R.V.J.)

**17378** RADIATION HEAT TRANSFER IN CERAMIC OXIDE FUEL ELEMENTS. Stoddard, J. A.; McCormick, N. J. (Univ. of Washington, Seattle). Nucl. Sci. Eng.; 39: 126-9(Jan 1970).

The importance of radiation heat transfer in $UO_2$ was investigated for prototype fast reactors having ceramic oxide fuel. An indication of an optically thick approximation for radiative transport is also

obtained. It was found that the effect of radiation heat transfer on temperature profiles depends strongly on the crystalline state of the fuel. (J.R.D.)

17379 THE EFFECT OF STORED ENERGY ON MEASUREMENTS OF THERMAL DIFFUSIVITY DURING IRRADIATION. Carroll, R. M.; Perez, R. B.; Sisman, O. (Oak Ridge National Lab., Tenn.). Nucl. Sci. Eng.; 39: 123-6(Jan 1970).

Information is presented to show that stored energy should be considered in experiments conducted to measure thermal perturbations in fuels during irradiation. Results of experiments indicate that a fraction of fission fragment kinetic energy is transferred into potential energy by deformation of the lattice thus creating point defects. A dynamic equilibrium is reached between defect production and annealing processes during power operation so that more energy is available during irradiation than would be indicated after irradiation. (J.R.D.)

## Structure and Phase Studies

*Refer also to abstracts 17362 and 17376.*

17380 (COO-716-53) THE YTTERBIUM–CARBON SYSTEM: VAPORIZATION OF $YbC_{1.25+\gamma}$. Haschke, John M.; Eick, Harry A. (Michigan State Univ., East Lansing. Dept. of Chemistry). [1969]. 12p. CONF-700403-1. Dep. CFSTI.

For Presentation at 8th Rare Earth Conference, Reno, Nev.

The ytterbium carbon system, $YbC_\chi$, has been investigated over the composition range $0.33 \leq \chi \leq 2.00$; samples were prepared by direct reaction of the elements in sealed tantalum bombs. Tetragonal $YbC_{2.00}$, monoclinic $YbC_{1.25+y}$ ($0 \leq y \leq 0.16$), $YbC_{0.95}$, and dimorphic (fcc and rhombohedral) $YbC_{0.50\pm x}$ have been identified by x-ray diffraction and elemental analysis. A linear variation of the carbon-rich $YbC_{1.25+\gamma}$ phase boundary and the monoclinic b parameter with temperature have been observed. The equilibrium vapor pressure of gaseous ytterbium in the $YbC_{1.25+\gamma} - YbC_{2.00}$ two-phase region has been measured by a target collection Knudsen effusion technique. A partial phase diagram for the Yb–C system is proposed, third law enthalpy data for $YbC_{1.25+\gamma}$ are presented, and the variation of composition and lattice parameter is discussed. (auth)

17381 REFRACTORY OXIDE–METAL COMPOSITES: SCANNING ELECTRON MICROSCOPY AND X-RAY DIFFRACTION OF URANIUM DIOXIDE–TUNGSTEN. Gerdes, R. J. (Georgia Inst. of Tech., Atlanta); Chapman, A. T.; Clark, G. W. Science; 167: 979-80(13 Feb 1970).

Unidirectional solidification of a melt, consisting of uranium dioxide and 5 to 15 percent by weight of tungsten, formed well-ordered arrangements of tungsten fibers or plateleta in the uranium dioxide matrix. Fiber shape and orientation relations of the components indicate the development of several dominant growth modes. (auth)

17382 STOICHIOMETRY HYSTERESIS IN THE $PrO_x-O_2$ SYSTEM BELOW 500°C. THE TETRAVALENT STATE OF NEODYMIUM AND THE PREPARATION OF $NdO_2$. PARTS A AND B. Nikodem, Robert Bruce. Blacksburg, Va.; Virginia Polytechnic Inst. (1969). 145p.

Isotherms have been investigated at a temperature of 500°C and below, and at oxygen pressures from $10^{-6}$ mm to an upper limit of approximately 200 mm. The $PrO_x-O_2$ isotherms were measured using a quartz beam microbalance which enabled the continuous observation of small changes in the stoichiometry of the praseodymium oxide to be observed as a function of the oxygen pressure applied to the oxide. All of the isotherms exhibited stoichiometry hysteresis and, with the exception of two isotherms, hysteresis effects were observed to be between the limits of known regions of composition stability. The isotherms agreed with those previously studied; however, where there was disagreement, the discrepancies were postulated to be caused by previous errors in temperature measurement. The tetravalent neodymium compounds $NdF_4$ and $Nd(BF_4)_4$ were prepared as possible intermediate compounds in the synthesis of $NdO_2$. $NdO_2$, if prepared, would be a possible Moessbauer source for study of the $NdO_x-O_2$ system which could be undertaken in conjunction with a quartz beam microbalance investigation of the stoichiometry hysteresis of the system. Samples were obtained which analyzed iodometrically as 18.34% $NdF_4$ and 32.77% $Nd(BF_4)_4$; however, due to the insufficient degree of purity these compounds were not subjected to further reaction to produce the dioxide, $NdO_2$. (Disser. Abstr.)

17383 STUDIES OF $ThO_2-Y_2O_3-WO_3$ SYSTEM. Spitsyn, Vikt. I.; Pokrovskii, A. N.; Afonskii, N. S.; Trunov, V. K. (Moscow State Univ.). Dokl. Akad. Nauk SSSR; 188: 1065-8(1 Oct 1969). (In Russian).

Phase relations in this system at 1000 and 1200°C were established by heating stoichiometric amounts of the initial oxides. Melting temperatures were determined on a high-temperature microscope. Phase analysis was carried out on samples quenched at various temperatures. A hexagonal phase which is a solid solution on alpha-$Th(WO_4)_2$ as a base was found to exist at 1000°C in the region of 60 to 98 wt % $Th(WO_4)_2$. The cell parameters are given as a function of composition. A cubic phase of variable composition was found by quenching samples from 1200°C in liquid nitrogen. The lattice parameters are given. A phase diagram for the system is presented. (TTT)

17384 AN INVESTIGATION OF THE CERIUM–OXYGEN–NITROGEN SYSTEM. Manske, Kenneth James. East Lansing, Mich.; Michigan State Univ. (1969). 101p.

Thesis.

The cerium oxygen nitrogen ternary phase diagram has been partially characterized from an examination of x-ray powder diffraction data of samples with various cerium oxygen nitrogen compositions. These samples were prepared by arc melting cerium dioxide and nitride, which was also prepared by the arc melting process. X-ray powder diffraction patterns and micrographic examinations revealed the presence of four phases: cerium sesquioxide, cerium nitride, cerium metal, and a previously unreported cerium oxide nitride. Analysis of three different micrographically pure preparations of this cerium oxygen nitrogen phase gave the following weight percentages: cerium, 88.33 ± 1.11%, nitrogen, 4.84 ± 0.17%; oxygen (by difference), 6.83 ± 1.12% (composition $CeN_{0.55\pm0.02}\ O_{0.68\pm0.11}$). X-ray powder diffraction photographs, indexable on face-centered cubic symmetry, yielded a lattice parameter of $a_0 = 5.115 \pm 0.002$ Å. Pulverized samples of this phase underwent no apparent reaction upon exposure to moist air for periods of up to two days. However, treatment with 6 M HCl yielded bubbles of a gas thought to be hydrogen. When the phase was struck with a hard object it could be made to spark and immediately oxidize to $CeO_2$. This oxide nitride phase upon heating to 1400° in vacuum lost nitrogen according to the following equation: $CeN_{0.55}\ O_{0.68}\ (s) \xrightarrow{1400°} CeN_{0.55} - \chi\ O_{0.68}\ (s) + (x/2)\ N_2\ (g)$. As the phase became deficient in nitrogen, its lattice parameter decreased. Further decrease in the nitrogen content during heating yielded a two phase mixture of the nitrogen deficient oxide nitride ($\sim CeN_{0.42}\ O_{0.80}$) and the sesquioxide. Cerium oxide nitride samples confined in a tungsten crucible and heated at 1200° in an ammonia atmosphere yielded the nitride and sesquioxide according to the reaction: $5.88\ CeN_{0.55}\ O_{0.68}\ (s) + 0.667NH_3\ (g) \rightarrow 3.88\ CeN(s) + Ce_2O_3\ (s) + H_2O(g)$ whose validity was confirmed by calculation of the free energy at selected temperature. The properties of this oxide nitride are discussed in comparison with those of other metal oxide nitride phases. (Disser. Abstr.)

17385 TUNGSTEN–TITANIUM–BORON METASTABLE PHASE DIAGRAM AT ROOM TEMPERATURE. Ariel, E. (Israel Ministry of Defence, Haifa); Barta, J.; Niedzwiedz, S. J. Less-Common Metals; 20: 199-206(1970).

A ternary phase diagram for the W–Ti–B system at room temperature is presented. The boron corner could not be determined owing to sublimation during melting and solid solubility ranges for the different phases were not derived. Specimens were arc-melted under a protective atmosphere and carefully homogenized. Analyses were carried out by chemical methods, optical metallography, electron micro-probe, and x-ray diffraction. All borides were identified as the high-temperature allotropic modifications due to the very slow rates of diffusion in this system, and the phase diagram as determined represents a metastable state. (auth)

17386 SOLUBILITY OF OXYGEN IN ZIRCONIUM CARBIDE. Zainulin, Yu. G.; Alyamovskii, S. I.; Shveikin, G. P.; Geld, P. V. (Inst. of Chemistry, Moscow). Izv. Akad. Nauk SSSR, Neorg. Mater Mater.; 6: 118-19(Jan 1970). (In Russian).

Oxygen diffusion into ZrC and the structure of oxycarbides of zirconium, $ZrC_{0.72}$, $ZrO_2$, zirconium hydride, and carbon black were studied. The initial specimens were sintered at 1700°C in a vacuum of $10^{-6}$ to $10^{-7}$ Hg mm for 80 to 90 hr. Isothermal cross section of the ternary system of Zr–O–C is given. At the maximum synthesis temperature of 2200°C $ZrO_2$ was found in the specimens by chemical analysis showing that complete solubility of the ZrC–ZrO was not achieved. (R.V.J.)

17387 PHASE DIAGRAM OF THE CONDENSED STATE OF $BaF_2-YF_3$ SYSTEM. Ippolitov, E. G.; Maklachko, A. G. (Inst. of General and Inorganic Chemistry, Moscow). Izv. Akad. Nauk SSSR, Neorg. Mater.; 6: 146-8(Jan 1970). (In Russian).

Differential-thermal and x-ray analyses were made of condensed $BaF_2-YF_3$ systems in purified argon. It was found that the melting point of $BaF_2$ and $YF_3$ was 1340 ± 5° and 1135 ± 5°C

respectively. The phase-diagram of the system was constructed and analyzed. (R.V.J.)

## Radiation Effects

*Refer also to abstracts 16740, 17329, 17339, 18585, 18674, 18699, 18724, 18725, and 18728.*

**17388** (CONF-690910–, pp 165-83) APPARATUS FOR MEASURING IN-PILE CREEP OF LMFBR CANDIDATE FUELS. Robinson, R. A.; Basham, S. J. Jr. (Battelle Memorial Inst., Columbus, Ohio).

The design and operation of an apparatus to obtain data on the compressive creep of ceramic fuel materials during irradiation are described. The specimen ($UO_2$ or $UO_2$–$PuO_2$) is fabricated in the shape of an annular cylinder to reduce temperature gradients caused by fission heating. A compressive load is applied to the specimen through a bellows-sealed, gas-actuated piston. Specimen temperatures are maintained by a resistance-wire heater. Axial creep of the fuel is measured by transmission of the motion through bellows-sealed probes that are linked to a variable-area-orifice, pneumatic displacement transducer. The equipment is designed to operate with fuel temperatures in the range 900 to 1300°C, stress levels of 3,000 to 12,000 psi, and fission rates ranging up to $2 \times 10^{13}$ fissions/cc-sec. Data are presented on the in-pile and out-of-pile creep characteristics of $UO_2$ specimens as measured in initial tests to check the operation of the equipment. (auth)

**17389** (CONF-690910–, pp 516-32) A MICROPROBE STUDY OF THE RETENTION OF THE FISSION GAS XENON IN IRRADIATED URANIUM FUELS DISPERSED IN ALUMINUM-CLAD NUCLEAR REACTOR FUEL PLATES. Zelezny, W. F.; Gibson, G. W.; Graber, M. J. (Idaho Nuclear Corp., Idaho Falls).

A number of techniques to enable the examination of irradiated and highly radioactive materials by microprobe are described. A number of applications of these techniques for the location and identification of fission products in and around irradiated dispersion fuel particles are outlined, with special emphasis on a technique for the semi-quantitative comparison of the proportion of the fission gas xenon, retained by $UAl_4$ and $U_3O_8$ dispersion fuel particles. It was found that $UAl_4$ retained xenon more effectively than $U_3O_8$ under irradiation at 125°C. It is believed that this technique could make a contribution in the study of fission gas (or other fission product) retention and migration in other fuel systems. (auth)

**17390** (CONF-690910–, pp 631-6) EXPERIENCE WITH INSTRUMENTED CAPSULES FOR HIGH TEMPERATURE IRRADIATION OF FUEL FORMS. Reilly, H. J. (National Aeronautics and Space Administration, Cleveland, Ohio. Lewis Research Center).

Experience with a first generation $UO_2$-fuel, tungsten-clad test capsule was used to make substantial improvements in the second generation capsule. Also the experience resulted in two changes in PBRF practices in experiment design: Mock-Up Reactor measurements are required for prediction of flux perturbation factor for fueled experiments and uncertainty analyses are required for all experiments. An experimental program was initiated to give more accurate ways of predicting perturbation factors and a calculational program was initiated to give more information on gamma heating in tungsten. An experimental program to measure relative heating in specimens of varying atomic number and thickness is underway. (auth)

**17391** (CONF-690910–, pp 637-51) ASSEMBLIES FOR THERMAL AND FAST FLUX IRRADIATION OF (UPu)N FUELS. Fromm, E. O.; Miller, N. E. (Battelle Memorial Inst., Columbus, Ohio).

The irradiation behavior of mixed uranium-plutonium fuels is being investigated as a part of the program on the development of mixed nitride fuels for high-gain LMFBR's. Both thermal and fast neutron irradiations are being performed; irradiation conditions include fuel burnups to 150,000 MWd/t, cladding temperatures to 700°C and fission heat generation rates in excess of 40 kW/ft. The thermal irradiation capsule experiments are being performed in the MTR and ETR to serve as a basis for planning the fast flux irradiations in EBR-II. (auth)

**17392** (IN-1335, pp 25-82) REACTOR FUELS AND MATERIALS DEVELOPMENT. (Idaho Nuclear Corp., Idaho Falls).

Results of destructive examination of five ETR boron-foil fuel elements indicate that this type of fuel element can safely be used in low and medium power positions (less than 2.0% of reactor power) of the ETR. Testing is continuing in high power positions. Three full-sized 2219 aluminum alloy clad fuel elements have been successfully tested in ETR. Progress on sample plate irradiations in the G-12 pressurized water loop of the ETR, capsule irradiations in the MTR and ETR, and postirradiation examinations is discussed. Irradiation testing of sample fuel plates fabricated by experimental rolling procedures has shown it is possible to produce plates containing semibonded regions which will pass nondestructive testing, but which do not have the required bond integrity for reactor use. This suggests that it is necessary to qualify fabrication procedures by destructive as well as nondestructive means, and that the reliability of the fuel plates depends on the fabricator's ability to repeat qualification procedures consistently. The good blister resistance of the uranium aluminides, whether dispersed in aluminum or stainless steel, is attributed to fission gas retention capability of this material and the almost negligible tendency for gas bubble agglomeration in the $UAl_3$. Blister mechanism observations of $UAl_x$–Al dispersions show that the aluminum matrix reaches its limit to retain fission recoil gas before any indication of gas retention problems appear in the $UAl_x$. Pure $UAl_3$ has shown gas retention capabilities up to 1250°C or just below the melting point. Under similar irradiation conditions (heat generation rate and surface temperature), the fission gas retention in $UAl_3$ is considerably better than $UO_2$. Gamma scanning of prototype reactor fuel plates in which $^{60}Co$ tagged boron glass was incorporated indicates that this is a satisfactory means of assaying for boron and that the gamma activity from the $^{60}Co$ does not interfere with the assay for $^{235}U$. Improved procedures were developed for the preparation of the $^{60}Co$ tagged boron glass to ensure that the $^{60}Co$-boron ratio is uniform throughout the glass and that the proper particle sizes of glass powder can be prepared. A prototype radiograph densitometer was constructed to measure fuel density on sample fuel plate radiographs and a computer program was written to treat the output data. Radiograph standards were designed to calibrate the system according to present ATR fuel loading specifications. The postirradiation examination of 55 wt % UAl alloy powder fuel cores shows that these core types compare favorably with $UAl_x$ + Al fuel dispersions from both a swelling and a blister standpoint and may offer an acceptable fabrication procedure. Zircaloy-2 exposed to emergency core cooling conditions becomes embrittled as a result of an oxygen saturated $\alpha$ phase layer which forms on the surface. A comparison of the compressive yield strengths of irradiated and unirradiated standard ETR fuel plates at various temperatures has been made. Preliminary results show that the ETR composition fuel plates have a loss in strength at the end of a normal operating cycle. (auth)

**17393** (ORNL–4480, pp 3-35) DEVELOPMENT OF FAST-REACTOR OXIDE FUELS. (Oak Ridge National Lab., Tenn.).

From Fuels and Materials Development Program Quarterly Progress Report.

Pellets were fabricated for two irradiation test capsules. Capsule GCFR P-9 for the Gas-Cooled Fast Reactor (GCFR) required 91% dense dished-end annular pellets of $(U_{0.88},Pu_{0.12})O_2$. Capsule ORR SG-3 for the Oak Ridge Research Reactor (ORR) required 83% dense annular pellets made from $(U_{0.80},Pu_{0.20})O_2$. Two capsules were fabricated for transient tests in the Transient Reactor Test Facility (TREAT). Although the maximum desirable gas release from fuel at 1600°C is 0.05 $cm^3/g$ (STP), releases as high as 0.3 to 0.50 $cm^3/g$ were recorded for pellet fuels. This high gas content is probably due to pickup of water during storage of the pellets, and the amount of gas absorbed is proportional to the amount of open porosity in the pellets. Means have been devised to protect the fuel from moisture during storage. An initial experiment was performed to determine the oxidation state of rare earths dissolved in $(U,Pu)O_2$ fuels. Results of a study with $Eu_2O_3$ in $UO_2$ indicated that Eu is oxidized from the +3 state to a higher state, thus indicating the O potential of a fuel element will not rise as rapidly during burnup as previously feared. Data from additional comparative tests of ammonium-diuranate (ADU) and sol-gel $UO_2$ specimens indicate that the deformation of $UO_2$ at high temperature under constant strain rates is more sensitive to grain size than to the density of the specimen. The compressive creep of $UO_2$ sol-gel specimens was measured under constant stress of 4910 psi between 1200 and 1400°C. A sol-gel Sphere-Pac capsule containing $(U,Pu)O_2$ attained a burnup of 7.5% fissions per initial metal atom (FIMA) in the Engineering Test Reactor (ETR), and, after interim neutron radiographs of the capsule showed no significant changes in the fuel rods or capsules, approval was obtained from the ETR Safety Review Committee to continue the irradiation to 10% FIMA burnup. The second instrumented capsule irradiated in the ORR, which contained two identical Sphere-Pac $(U,Pu)O_2$ fuel rods with 81% smear density, was removed from the reactor after operating normally at temperatures up to 1500°C at the fuel center. This capsule, SG-2, is now undergoing postirradiation examination. An instrumented capsule was designed for irradiation in ETR. The hazards analysis, test specifications, and operating

manual for the TREAT capsules were completed, submitted to the TREAT staff, and accepted by them with minor revisions. Encapsulated tests of Sphere-Pac $(U,Pu)O_2$ fuel rods in subassembly X050 in the Experimental Breeder Reactor-II (EBR-II) reached a peak burnup of 3.1% FIMA, or about 63% of the currently scheduled burnup. (auth)

17394 (ORNL-4480, pp 149-51) DEVELOPMENT OF URANIUM MONONITRIDE FUELS. (Oak Ridge National Lab., Tenn.).

From Fuels and Materials Development Program Quarterly Progress Report.

The third capsule for irradiation testing of UN has operated successfully for 4500 hr with cladding temperatures up to 1400°C. The cladding is T-111 (Ta-8% W-2% Hf). (auth)

17395 (ORNL-4480, pp 188-95) FAST-NEUTRON IRRADIATION EFFECTS ON ELECTRICAL INSULATORS. (Oak Ridge National Lab., Tenn.).

From Fuels and Materials Development Program Quarterly Progress Report.

Silicon oxynitride ($Si_2ON_2$) changed very little in volume during irradiation over the fast-fluence range 1.6 to $5.5 \times 10^{21}$ neutrons/cm² (>1 MeV) at temperatures below 100°C. There is an initial shrinkage followed by expansion at high fluences. Translucent Lucalox $Al_2O_3$ was irradiated at 70 to 90°C to fast fluences ranging from 1.8 to $5.5 \times 10^{21}$ neutrons/cm² (>1 MeV). The volume expansion at high fluences (above $3.6 \times 10^{21}$ neutrons/cm²) was very much less than was previously observed in irradiations at higher temperatures. An assembly containing combinations of insulators and metallic conductors was irradiated in the Engineering Test Reactor. Postirradiation examinations are in progress. (auth)

17396 (ORNL-4480, pp 209-12) FISSION-GAS RELEASE AND PHYSICAL PROPERTIES OF FUEL MATERIALS DURING IRRADIATION. (Oak Ridge National Lab., Tenn.).

From Fuels and Materials Development Program Quarterly Progress Report.

Thermal diffusivity data obtained during irradiation have indicated that stored energy is present in two forms: one part results from long-term buildup with irradiation and one depends on the immediate irradiation history. The data-measuring and -processing techniques work with high precision. The mathematical processes for obtaining values of thermal diffusivity need further development because of the erratic release of stored energy. Fission-gas release from the specimen shows that it remains in good condition. (auth)

17397 (ORNL-4480, pp 245-55) BEHAVIOR OF REFRACTORY MATERIALS UNDER IRRADIATION. (Oak Ridge National Lab., Tenn.).

From Fuels and Materials Development Program Quarterly Progress Report.

Refractory-metal carbides were irradiated at temperature between 65 and 130°C to fast fluences from 0.1 to $0.7 \times 10^{21}$ neutrons/cm² (>1 MeV). Initial slopes of the curves for $\Delta V/V$ versus fast fluence were obtained from the data plots: TiC, 0.24; ZrC, 0.22; TaC, 0.15; NbC, 0.14; WC, 0.24. Specimens that had previously been irradiated at 175 to 400°C were annealed out-of-reactor at temperatures up to 1100°C. In each case, there was a rapid reduction in fractional volume increase followed by a leveling off at 900 to 950°C. The annealing data aided in the development of a mechanism for neutron damage, based on irradiation annealing, that explains the initial saturation of volume expansion of carbides. A low-temperature (about 150°C) assembly containing depleted nitride fuel specimens is now being irradiated in the Engineering Test Reactor. A high-temperature (1000°C) assembly is being prepared for a similar irradiation. These experiments are designed to evaluate the effects of He generation in nitride fuels through the $^{14}N(n,\alpha)^{11}B$ fast reaction by comparing property changes of specimens made with $^{14}N$ with those of specimens made with $^{15}N$, which does not undergo the $(n,\alpha)$ reaction. Assemblies are being designed and specimens are being prepared for irradiation of fast-neutron absorbers in the Experimental Breeder Reactor-II blanket. Specimens of $B_4C$ of two different B:C ratios, Ta metal, TaC, and other absorbers will be irradiated at 400 and 750°C. (auth)

17398 FISSION RECOIL DAMAGE TO PYROLYTIC CARBON. Bokros, J. C. (Gulf General Atomic Inc., San Diego, Calif.). Carbon; 7: 703-6(Dec 1969).

To determine the nature of the damage expected in carbon coatings near the end of fuel element life, fission product irradiations were performed at 1200 to 1300°C with exposures of $2 \times 10^{18} - 3 \times 10^{18}$ fission recoils/cm². Damage depended upon the structure of the coating, high-density isotropic or granular carbons being much more susceptible than low-density isotropic carbon. (UK)

17399 THERMAL ANNEALING OF PYROLYTIC GRAPHITE IRRADIATED WITH FAST NEUTRONS AT 40°C. Kelly, B. T. (United Kingdom Atomic Energy Authority, Culcheth, Eng.). Carbon; 7: 699-700(Dec 1969).

Highly oriented pyrolytic graphite was irradiated to $1.42-40.2 \times 10^{18}$ nvt. Dimensional changes were measured parallel to the hexagonal axis of the compound crystals, and thermal conductivity was measured parallel and perpendicular to this direction. Properties were remeasured after ½ hr anneals at temperatures up to 1500°C. It is concluded that recovery, which was complete at 1250°C, is due to the release of interstitial atoms from traps or weakly bonded interstitial atoms, to vacant lattice sites. (UK)

## Plastics and Other Materials

*Refer also to abstracts 16585, 16694, 16739, 16787, 17195, 17274, and 18790.*

17400 EFFECTS OF $^{60}Co$ RADIATION ON DIELECTRIC PROPERTIES OF POLYAMIDE SAMPLES AT 10 GHz. Sauerbrey, H.; Suhr, H. (Physikalisch-Technische Bundesanstalt Institut, Berlin). Kolloid-Z. Z. Polym.; 235: 1171-3(1969). (In German).

The dielectric properties of two polyamide samples (6- and 6,10-polyamide) were investigated at 10 GHz during and after irradiation using $^{60}Co$ γ radiation (doses $\leq 8 \times 10^8$ R) at temperatures between 77 and 360°K. The irradiation caused changes in lattice bond and a decrease in crystallinity was observed by means of the temperature dependences of the relative dielectric constant and of the dielectric loss factor. The glass transition temperatures of both substances were enhanced with increasing γ dose. (auth)

17401 CONCRETE. Lankard, D. R. Reactor Mater.; 13: 42-3(Spring 1970).

A review on creep and radioactivity of concrete is summarized. Factors affecting creep in PCPV concretes include temperature, moisture, and internal pressure. Uranium and thorium contribute more radioactivity to concrete raw materials than potassium does, owing to specific gamma radioactivity relative to potassium. The radioactivity of portland cements and the initial raw materials was also studied. (J.C.W.)

17402 CASTABLE NEUTRON SHIELD. Faler, Kenneth T. (to United States Atomic Energy Commission). U. S. Patent 3,471,414. 7 Oct 1969.

A composition consisting of 4 to 6 parts $^6Li$ carbonate or hydroxide and 1 part long-chain fatty acid or mixture of fatty acids is suitable for use as a neutron shield. The material provides a low γ-ray background and can be cast, recast, shaped, carved, machined, or drilled into the desired shape. (B.L.M.)

17403 RADIATION EFFECTS AND APPLICATIONS ON TEXTILE POLYMERS. Com. Naz. Energ. Nucl., Notiz.; 15: No. 12, 100-2(Dec 1969). (In Italian).

A discussion of certain new properties conferred by nuclear radiations on natural and artificial fibers is presented. (auth)

17404 EFFECTS OF HIGH ENERGY RADIATIONS ON INSULATORS. Belloc, P.; Fallou, B. (Laboratoire Central des Industries Electriques, Fontenay-aux-Roses, France). Rev. Gen. Elec.; 79: 69-72(Jan 1970). (In French).

Properties of different insulators were tested after gamma and electron irradiation. Changes in insulator mechanical properties give quite a good idea of the damages they incurred. (auth) (France)

17405 MEASUREMENT OF THE PERMEABILITY OF PAINT FILMS. Deterding, J. H.; Wilson, R. W. (Shell Research Ltd., Chester, Eng.). 15p. of Measuring Methods in Corrosion Protection. Vol. 3. Prague; Czechoslovak Scientific and Technical Society (1968).

From 42nd Conference of the European Federation of Corrosion, Prague, Czechoslovakia. See CONF-681077-(Vol.3).

An experimental technique is described for measuring water permeability through paint films using tritiated water, chlorine-36, and sodium-22 as tracers. Possible sources of error for measuring the transfer rates of sodium and chloride ions were studied. Equilibrium water transfer rates across a particular film are the same regardless of whether there is water on one side of the film or on both sides. The presence of salt has no measurable effect on water transfer rates. An evaluation of the technique was made. (J.C.W.)

# PHYSICS (GENERAL)

## Astrophysics and Cosmology

*Refer also to abstract 18040.*

### Cosmic Ray Exposure Ages

17406 POSSIBLE EXISTENCE OF TRACES OF DECAYED SUPERHEAVY ELEMENTS IN METEORITES. Dakovskii, M. (Inst. for Nuclear Research, Warsaw). Izv. Akad. Nauk SSSR, Ser. Fiz., 33: 1256-8(Aug. 1969). (In Russian).

It is noted that the content of fission xenon is anomalously high and cannot be accounted for by the $^{244}$Pu content. The half-life of $^{244}$Pu is $8.18 \times 10^7$ years for alpha decay and $6.55 \times 10^{10}$ years for spontaneous fission. In addition, it is found that the krypton content in various chondrites is anomalously low, and cannot be explained by means of $^{244}$Pu fission. It is pointed out that if superheavy elements were formed in the stability region Z = 114 and A = 184, the superheavy isotopes would almost certainly undergo spontaneous fission in the process of undergoing successive alpha and beta decays. The overall fission probability is close to one. With a half-life of $10^8$ years the amount of superheavy isotope required to explain the xenon anomaly in chondrites is two orders of magnitude less than the amount of required $^{244}$Pu. The krypton anomaly can also be explained by assuming the existence of symmetrical fission in superheavy elements with one of the peaks in the region of the xenon isotopes. (TTT)

17407 EXTINCT RADIOACTIVITIES. Cameron, A. G. W. Comments Astrophys. Space Phys.; 2: 18-24(Jan-Feb 1970).

There are some radioactivities having half-lives in the intermediate range, $10^6$ to $10^8$ years, which give valuable information about the early history of meteorite parent bodies and the solar system. Extinct nuclides discussed include $^{244}$Pu, $^{26}$Al, $^{129}$I, and $^{298}$114. (W.D.M.)

17408 $^{26}$Al–$^{26}$Mg DATING OF FELDSPAR IN METEORITES. Clarke, W. B.; de Laeter, J. R.; Schwarcz, H. P.; Shane, K. C. (McMaster Univ., Hamilton, Ont.). J. Geophys. Res.; 75: 448-62(10 Jan 1970).

A search for "fossil" $^{26}$Mg from the decay of 0.72 m.y. $^{26}$Al in an aluminum-rich (plagioclase feldspar) phase of several stone meteorites was carried out. An electron impact ion source in a tandem mass spectrometer was used for a series of measurements of the relative abundances of stable magnesium isotopes in meteoritic and terrestrial feldspar, as well as in unseparated ("common") magnesium from meteorites, from meteoritic chondrules, and from laboratory reagents. Relative to terrestrial magnesium, the meteorites Bruderheim and Khor Temiki show a definite $^{26}$Mg excess (4 to 6‰). Haraiya and Mocs also show this effect although the experimental evidence is not nearly as secure as in the first two examples; Moore County is a borderline case. Magnesium contents of the separated feldspar phases were measured by isotope dilution, allowing a calculation of $^{26}$Mg (radiogenic), relative to Si = $10^6$ atoms for the meteorites. The following conclusions can be made: (1) the feldspar of some meteorites cooled to below the temperature of appreciable Mg diffusion (~650°C) within a time spread of about 3 m.y.; (2) only a short time (≤5 m.y.) could have elapsed between the end of $^{26}$Al production and formation of the feldspar phase in some meteorites; (3) the process that produced $^{26}$Al early in the history of the solar system (most probably solar proton irradiation of surrounding material) was of short duration (<5 m.y.); (4) if the levels of $^{26}$Al deduced from measurements of excess $^{26}$Mg were present at the time of formation of objects a few tens of km in radius, sufficient energy would have been produced by radioactive decay of $^{26}$Al to heat the centers of these objects to near their melting points. (auth)

17409 $^{87}$Rb–$^{87}$Sr AGE OF CARBONACEOUS CHONDRITES. Kaushal, Sushil K.; Wetherill, George W. (Univ. of California, Los Angeles). J. Geophys. Res.; 75: 463-8(10 Jan 1970).

Nine carbonaceous chondrites were analyzed for potassium, rubidium, and strontium elemental concentrations and Sr isotopic composition. Two additional carbonaceous chondrites were analyzed for K and Rb concentrations only. Possibly because of Rb and Sr contamination, the type 1 carbonaceous chondrites Orgueil and Ivuna, and the type 2 chondrites Cold Bokkeveld and Erakot, do not fall on the bronzite isochron, which has an age of 4.69 b.y. assuming $\lambda(^{87}\text{Rb}) = 1.39 \times 10^{-11}$ year$^{-1}$, and $^{87}$Sr/$^{86}$Sr initial ratio of 0.6983. The type 2 and types 3 or 4 carbonaceous chondrites Haripura, Mokoia-B, Essebi, Mighei, and Pueblito de Allende fall on the bronzite isochron within experimental error. There is no evidence for the previously published suggestion that the type 3 carbonaceous chondrites were formed by metamorphism from type 1 carbonaceous chondrites 300 m.y. later by Rb depletion. Rb and Sr elemental variations show an opposite trend. Rb and K concentrations are higher and Sr concentration is lower in type 1 than in type 2 and type 3 carbonaceous chondrites. Unlike the large variation of K/Rb ratio in bronzite chondrites and amphoterite chondrites, the carbonaceous chondrites show an almost uniform K/Rb ratio of about 240. (auth)

17410 REGULAR DISCONTINUITIES IN THE COMPOSITION OF METEORITES. Wiik, H. B. Soc. Sci. Fenn., Comment. Phys.-Math.; 34: 135-45(13 Nov 1969).

In meteorites the weight per cent of the elements and the weight per cent of their isotopes form geometric series. The buildup of these series is the same for all elements and isotopes. These regularities are inconsistent with a random mixture, or products formed by gravitational differentiation of selective volatilization. (auth) (Finland)

### Stars

*Refer also to abstracts 16915, 17586, and 17587.*

17411 METHODS OF MULTI-COLOR POLARIZATION OBSERVATIONS OF THE STELLAR RADIATION. Efimov, Yu. S.; Polosukhina, N. S.; Shakhovskoi, N. M. Izv. Krym. Astrofiz. Observ.; 39: 3-10(1969). (In Russian).

The methods and apparatus used for multicolor polarization observations of variable stars are described. The dependence of the instrumental polarization on the wavelength is obtained. The accuracy of observations (~0.1%) is estimated. The obtained results are compared with the data of other authors. The possibility of the application of narrow-band interference filters for precise polarization measurements is shown. (auth)

17412 INTRINSIC POLARIZATION OF RED GIANTS AND SUPERGIANTS. Shakhovskoi, N. M. Izv. Krym. Astrofiz. Observ.; 39: 11-33(1969). (In Russian).

Observations of polarization of stars $\mu$ Cep, R Sct, V CVn, and R Aqr in three colors (U, B, V) were carried out. New methods of the analysis of multicolor polarization observations, based on the existence of correlation between parameters of the intrinsic polarization in different colors and on the use of a known dependence of the interstellar polarization on the wavelength, were worked out. For stars $\mu$ Cep, R Sct, V CVn, R Boo, RS Cnc, S CrB, U Her, R Leo, Z UMa the polarization of their proper radiation is separated from the interstellar polarization. Previous data were used together with the results of the observations. (auth)

17413 POLARIZATION OF THE RADIATION OF MAGNETIC-VARIABLE STARS. Polosukhina, N. S. Izv. Krym. Astrofiz. Observ.; 39: 34-41(1969). (In Russian).

Results of measurements of polarization of magnetic stars in three colors with $\lambda_{eff}$ 3550, 4350, 5300 Å are given. The dependence of the degree of polarization (p) on the wavelength $\lambda$ for magnetic stars HD 71866, $\beta$ CrB, HD 215441 is obtained. The dependence of p on $\lambda$ changes for HD 215441, the polarization of which changes irregularly. (auth)

17414 ON OBSERVATIONS OF THE LIGHT POLARIZATION OF AD LEO. Efimov, Yu. S. Izv. Krym. Astrofiz. Observ.; 39: 42-3(1969). (In Russian).

Results of two-color polarized observations of AD Leo are given. The considerable difference between position angles of polarization planes in blue and yellow parts of the spectrum is found. (auth)

17415 THE SPECTROPHOTOMETRIC INVESTIGATION OF THE CLOSE BINARY SYSTEM HD 190918. Galkina, T. S. Izv. Krym. Astrofiz. Observ.; 39: 44-62(1969). (In Russian).

The analysis of the composite spectrum of HD 190918 was carried out on the basis of spectrograms, obtained in 1963–1964 (dispersion 37 Å/mm) in the region 4900 to 3600 Å. The supposition on the variability of the spectral class of the absorption component from 09.0 to 08.0 is expressed on the basis of the analysis of the absorption lines in the spectrum of HD 190918. The spectral class of the emission component is estimated as WN5.5. The detailed investigation of the contour of the emission band $\lambda$4686 He II leads to the conclusion on the orbital motion of components of HD 190918 with the period of about 105 days. The change of the emission intensity $\lambda$4686 He II both in the interval of one season

and from season to season is discovered. Measurements of the emission band λ4686 He II showed its systematic displacement to the long-wave part of the spectrum by 110 km/sec relative to the absorption component. (auth)

17416 AN INVESTIGATION OF HIGH VELOCITY EARLY-TYPE STARS (RUN-AWAY). II. Vitrichenko, E. A. Izv. Krym. Astrofiz. Observ.; 39: 63-95(1969). (In Russian).

The equivalent linewidths of 13 experimental and 5 standard stars are determined from spectrograms, obtained with the grating spectrograph of the 122-cm reflector of the Crimean observatory (dispersion 15 and 37 Å/mm). No pecularities differentiating fast stars from standard ones were found in the line spectrum. The two-dimensional quantitative classification of the experimental and standard stars is given. The content of helium with respect to hydrogen, determined by two independent methods was found to be equal in fast and standard stars. Velocities of rotation (v sin i) of 13 fast stars were determined. The distribution of rotation velocities of 34 fast stars is more like the distribution of rotation velocities of spectral binaries than that one of single stars. Elements of HD 3950 orbit are made more precise. The variability of the radial velocity of HD 188439 was not corroborated. The variability of the radial velocity of HD 167330, HD 167451, and HD 175514 was corroborated. The percentage of binaries among these stars was 20 to 45%. The method of the determination of radial velocities of OB stars with a grating spectrograph is described. (auth)

17417 ON STARS OF RW AUR TYPE AND IRREGULAR VARIABLES (Ia) OF EARLY SPECTRAL CLASSES. Rachkovskaya, T. M. Izv. Krym. Astrofiz. Observ.; 39: 96-107(1969). (In Russian).

Spectra of BU Tau and V923 Aql stars of Ia type and spectra of normal stars are compared on the basis of spectrograms, obtained with dispersion 15 Å/mm. The difference in spectra of comparable stars is explained by the fact that the variable stars BU Tau and V923 Aql have shells. The star V923 Aql has a deficit of hydrogen. Values of the electron density lg $n_e$ = 12.86 and velocities $v_D$ = 36 km/sec, obtained for the shell of V923 Aql, indicate that the shell of V923 Aql is more rarefied than the atmosphere of the supergiant 6 Cas A. The comparative investigation of 10 variable stars of RW Aur and Ia types show: (1) there is no noticeable difference in the chemical composition of comparable variable and normal stars; (2) for the majority of variable stars electron densities are somewhat higher than for normal stars; (3) the hydrogen–helium ratio in early B stars of indicated types is the same as in normal stars. All variables investigated, with the exception of 3 Be stars, are disposed by the lower boundary of the main sequence and below their stars of comparison. This indicates the young age of the variable investigated. (auth)

17418 ON SOME PECULIARITIES OF THE ATMOSPHERE OF γ UMi. Leushin, V. V. Izv. Krym. Astrofiz. Observ.; 39: 108-13(1969). (In Russian).

The equivalent widths of hydrogen lines and that of some metals are measured. The variability with P = 0.108449 d of lines $H_{11}$ to $H_{39}$ and some metallic lines is discovered. The analysis of curves of growths for Fe I and Fe II is carried out, giving $v_t$ (Fe I) = 1.8 km/sec and $v_t$ (Fe II) = 3.6 km/sec. The electron pressure lg $P_e$ = 1.66 by H and lg $P_e$ = 0.95 by Fe was determined. (auth)

17419 ABSORPTION BANDS OF TITANIUM MONOXIDE OF α-SYSTEM IN STELLAR SPECTRA OF M CLASS. Boyarchuk, M. E. Izv. Krym. Astrofiz. Observ.; 39: 114-23(1969). (In Russian).

Absorption bands of TiO were investigated on the basis of 110 spectrograms of 28 stars of M0 to M8 spectral classes. The identification of α-system titanium bands in the stellar spectra was carried out. Intensities of band heads were estimated quantitatively. The intensity change of band heads of TiO with the spectral class is considered. (auth)

17420 THE SPECTROSCOPIC INVESTIGATION OF SYMBIOTIC STARS AX PER, CI CYG, AND BF CYG. Boyarchuk, A. A. Izv. Krym. Astrofiz. Observ.; 39: 124-39(1969). (In Russian).

Relative intensities of emission lines and the energy distribution in continuous spectra of AX Per, CI Cyg, and BF Cyg were obtained on the basis of 19 spectrograms (dispersion 80 Å/mm). The radial velocities, published earlier, were considered. It is shown that the data of observations can be explained by the supposition that the stars under investigation are binaries, consisting of the cold giant M5 III and a hot star of low luminosity. Both components are surrounded by a nebula with mass of ~$10^{30}$ g and $n_e$ ~ $10^7$ $cm^{-3}$. (auth)

17421 AN ESTIMATION OF AN UPPER LIMIT OF THE X-RAY FLUX OF THE FLARES OF UV CET TYPE STARS FROM A SUDDEN COSMIC NOISE ABSORPTION EFFECT. Gershberg, R. E.; Neshpor, Yu. I.; Chugainov, P. F. Izv. Krym. Astrofiz. Observ.; 39: 140-6(1969). (In Russian).

A search for a sudden cosmic-noise absorption during the flares of UV Cet-type stars was carried out; no effect was found. Supposing that the effect is smaller than the fluctuations of cosmic-noise recorders, the upper limit of a possible x-ray flux of the UV Cet-type star flares is estimated. During the strong flare of EV Lac $F_X < 10^{-4}$ erg/$cm^2$ sec and the ratio of a possible x-ray flux of the flare to the flux at the optical band B is $F_X/F_B < 10^5$. These estimations do not permit a choice between the possible mechanisms of the supposed x radiation of stellar flares. (auth)

17422 OBSERVATIONS OF FAINT FAST-VARIABLE STARS BY MEANS OF HIGH SENSITIVITY TELEVISION APPARATUS. Efimov, Yu. S.; Prokof'eva, V. V. Izv. Krym. Astrofiz. Observ.; 39: 163-9(1969). (In Russian).

Observations of the eclipsing variable RW Tri are carried out by means of the high-sensitivity television apparatus with an additional brightness amplifier. It is shown that this apparatus allows investigation of very fast variation of brightness of faint stars with telescopes of moderate size. The mean square error $\sigma_{\Delta m}$ of one measurement of magnitude differences of two faint stars is ±0.08 to ±0.10 m. (auth)

17423 FORMULAE AND GRAPHS FOR A QUANTITATIVE ANALYSIS OF THE FORBIDDEN-LINE RADIATION OF EMISSION OBJECTS. Boyarchuk, A. A.; Gershberg, R. E.; Godovnikov, N. V.; Pronik, V. I. Izv. Krym. Astrofiz. Observ.; 39: 147-62 (1969). (In Russian).

Working formulae and graphs necessary for a quantitative analysis of the forbidden-line radiation of emission objects are given. Results are precise and handy graphs are given for a quick determination of the physical conditions in radiant media by the Seaton "intersection of curves" method. The common scheme is considered for computer calculations of the ratios of line intensities and absolute line luminosities, accounting for the dependence of these values on electron temperature, electron density, temperature of ionizing radiation, and dilution coefficient. (auth)

17424 RADIAL OSCILLATIONS OF COMPOSITE POLYTROPES. PART I. Singh, Manmohan (Univ. of Roorkee, India). Proc. Nat. Inst. Sci. India, Part A; 35: 586-9(Jul 1969).

Composite polytropic configurations were obtained by taking polytropic indices as 1.5 and 3, respectively, in the core and envelope. Some numerical solutions of Emden equation were also developed. (auth)

17425 EMISSION LINES IN THE SPECTRA OF THE NOVA DELPHINI 1967 BETWEEN 8400 AND 9600 A. Andrillat, Yvette; Houziaux, Leo (Faculte des Sciences, Montpellier, France. Faculte des Sciences, Mons, Belgium). Compt. Rend., Ser. B; 269: 546-8(22 Sep 1969). (In French).

Two spectra of Nova Delphini 1967 between 8400 and 9600 Å were obtained using IM plates hypersensitive to ammonia. A microphotometric recording of the first spectrum E' 355 is given, and the spectra itself is reproduced with the same dispersion. A table is given showing the data for the emission wavelengths in E' 369, the second spectrum taken. It is noted that this spectrum has a double structure. The wavelengths of the observed components, the proposed identification, the variation between the observed wavelengths, the position of the lines measured in the laboratory, and the intensities of the lines are given in this table. (J.F.P.)

17426 HELIUM-RICH STARS OF EARLY SPECTRAL TYPE. Dinger, Ann S. (Northwestern Univ., Evanston, Ill.). Astrophys. Space Sci.; 6: 118-30(Jan 1970).

The properties of the known helium-rich stars of early type are reviewed and the elemental abundances are analyzed. Current evolutionary theories of mixing and mass loss may explain the origin of these stars. (auth)

17427 CORRELATIONS BETWEEN STATISTICAL POPULATION INDICES AND SPECTRAL CHARACTERISTICS OF CARBON STARS. Krempec, Janina (Astronomical Inst., Torun, Poland). Astrophys. Space Sci.; 6: 131-40(Jan 1970).

The coefficients of correlation between spectroscopic data published by Yamashita (1967) and others for carbon stars and the statistical population indices calculated for these stars at the Torun Observatory are calculated. The intensity estimates of Ca I λ4227 Å, Na I D lines, the $^{13}C/^{12}C$ ratio, the n = n(Li/Ca) index, as well as CN and probably $C_2$ bands are higher in population-I carbon stars. The CH(G) band and probably hydrogen (Hβ, Hγ, Hδ) lines as well as B II λλ4554 and 4934 Å lines are stronger in population-II carbon stars. The photoelectric color indices,

corrected for interstellar reddening do not show significant population effects. They can be used as spectral type equivalents. For a population criterion the CH/CN intensity ratio is proposed. (auth)

**17428 QUANTITATIVE ANALYSIS AND SPECTRAL VARIATION OF THE Ap STAR HD 151 199. Goekkaya, Nahide (Astronomical Observatory, Trieste, Italy). Astrophys. Space Sci.; 6: 141-53(Jan 1970).**

The radial velocity, intensity variations of the Ca II line, and chemical composition of the suspected magnetic star HD 151 199 were studied using three 9.6 A/mm and twenty-one 40 A/mm dispersion spectrograms taken at St. Michel and Asiago Observatories, respectively. The radial velocity and the intensity of the Ca II K line suggest a variation with a 6.143-day period. The range is about 40 km/sec for the radial velocity and the K line changes in intensity by 50%. Preliminary results of the photometric data in the Geneva system show a similar trend of variation in $\Delta(B_2-B_1)$ with the same period. H$\beta$ and H$\gamma$ contours and the Balmer discontinuity give $\theta_{eff} = 0.50$ and $\log g = 4$. The most probable microturbulence is found to be 6.4 km/sec. The excitation temperature, $\theta_{exc} = 0.50$, is derived from the Fe lines and adopted for the other elements as well. A quantitative analysis by curve of growth and weighting function method, using Mihalas and Conti's atmospherical models was made. HD 151 199 shows an overabundance of Ca, Sr, Ba, by factors of 2, 40, and 5 with respect to 30 L Mi. Eu II is probably overabundant also but it is not possible to give this element a numerical value. The other elements seem to be normal. (auth)

**17429 CONVECTION REGIONS AND CORONAS OF SUN AND STARS. De Loore, C. (Univ. of Brussels). Astrophys. Space Sci.; 6: 60-100(Jan 1970).**

Photospheric models were calculated for 90 stars with effective temperatures between 2500 and 41600 K for five log g-values ranging from 1 to 5. Molecule formation was taken into account. In order to have an idea about possible instabilities in the different stellar layers some quantities, characteristic for convection and turbulence were calculated, such as the Rayleigh, Reynolds, Prandtl, and Péclet numbers. It turned out that all the investigated stars contain unstable layers, including the hottest. Nevertheless, only stars with effective temperatures of 8300 K or less contain layers where the convective energy transport is important. For all stars the convective velocities were calculated and also the generated mechanical fluxes in the convection zones were tabulated. Under the hypothesis that this mechanical energy flux is responsible for the heating of the corona, coronal models were constructed for the Sun and for some stars with effective temperatures between 5000 K and 8320 K for the log g-values of 4 or 5. For main-sequence stars the largest fluxes are generated in F stars; stars with $T_{eff} = 7130$ K and $\log g = 4$ possess also the hottest and most dense coronas with a computed temperature of $3.7 \times 10^6$ K and $\log N_e = 10.5$. The solar corona computed in this way, on the basis of a photospheric mechanical flux of $0.14 \times 10^8$ erg cm$^{-2}$ sec$^{-1}$, has a temperature of $1.3 \times 10^6$ K and $\log N_e = 9.8$. This density is apparently too high, but even when including in the computations all theoretical refinements proposed in the last few years by various authors it does not appear possible to obtain a solar coronal model with a smaller density. However, when taking into account the inhomogeneous structure of the chromosphere and by associating the calculated mechanical fluxes to the coarse mottles, and lower fluxes to the undisturbed regions a mean coronal temperature of $1.1 \times 10^6$ K and a mean $\log N_e$ value of 9 are found. The computed velocity of the solar wind at a distance of $10^4$ km above the photosphere has a value between 7 and 11 km sec$^{-1}$. These latter values are in fair agreement with the observations. (auth)

**17430 PARTIAL DERIVATIVES OF ECLIPSE FUNCTIONS $\alpha^{oc}$ AND $\alpha^{tr}$. Jurkevich, I. (Univ. of Pennsylvania, Philadelphia. General Electric Co., Valley Forge, Pa.). Astrophys. Space Sci.; 6: 4-12(Jan 1970).**

Expressions are given for partial derivatives of eclipse functions with respect to geometrical depth, p, and the ratio of radii, k. The derivatives are evaluated for critical combinations of p and k at which indeterminacies occur and the resulting expressions are listed. All expressions are given in a form suitable for numerical evaluation. Notation employed is that of Merrill. (auth)

**17431 NEBULAR AND CORONAL LINES IN THE INFRARED SPECTRUM OF NOVA DELPHINI. Andrillat, Yvette (Faculte des Sciences, Montpellier, France); Houziaux, Leo. Astrophys. Space Sci.; 6: 36-44(Jan 1970). (In French).**

Nova Delphini 1967 has been observed in the red and photographic infrared at the Haute-Provence Observatory from September 7 to November 12, 1968. Dispersions range from 230 Å/mm to 4 Å/mm. The slope of the continuous spectrum in the region 1.3 to 1.7 $\mu^{-1}$ leads to a gradient of 3.06, which did not appear to vary during the observing period. This gradient is, however, very different from the value 1.71 measured on plates secured in August 1968. Lines of H I, He I, He II, Fe II, O I, C II and forbidden transitions due to O I, O II, Fe VII, Fe X, Fe XI, S III, A III, A V, A XI, and Ni XV have been identified. Their intensities at various dates are given. Line profiles could be measured for a few lines taken on a 39 Å/mm spectrogram on October 3. He I $\lambda$ 6678 and $\lambda$ 7065, the [O II] doublet at $\lambda$ 7319 to 7330, and the H$\alpha$ profile, obtained on October 4, are shown. The line extends over more than 45 Å and narrow absorptions are seen at $\lambda\lambda$ 6551.05; 6555.75; 6563.15; 6571.49; 6574.45. Due to the absence of published data on radial velocities of absorption lines in the visible spectrum at that time, it is not possible to give a clear identification for these features. Some of them may belong to H$\alpha$, while others are probably due to metals. (auth)

**17432 7 SEXTANTIS, A POSSIBLE RUN-AWAY STAR FROM UPPER CENTAURUS LUPUS. Martinet, L. (Observatoire, Geneva). Astron. Astrophys.; 4: 331-4(Feb 1970).**

It is suggested that the high-velocity A star 7 Sextantis could have been formed in the Upper Centaurus Lupus subgroup of the Scorpio-Centaurus association and ejection from it as a "run-away" Ap star, about $1.3 \times 10^6$ years. (auth)

**17433 INTRINSIC COLORS OF STARS AND TWO-COLOR REDDENING LINES. FitzGerald, M. Pim (Case Western Reserve Univ., Cleveland. Univ. of Waterloo, Canada). Astron. Astrophys.; 4: 234-43(Feb 1970).**

Mean intrinsic colors, on the Johnson UBV and Cape $U_cBV$ systems, are obtained for stars of all MK spectral classes by analysis of the data in the Photoelectric Catalogue (Blanco et al., 1968). The intrinsic colors of stars of a given MK class are determined from: (1) the average colors of unreddened stars, for A to M giants, sub-giants, and dwarfs; (2) blue-most envelopes in two-color and spectral-color diagrams, for A to M bright giants and supergiants, and also for O and B type stars; and (3) two-color reddening lines, for O and B type stars. The coefficients of the two-color reddening line equation, $E_u = \alpha E_y + \beta E_y^2$, are obtained for the early type stars. The mean slope, $\alpha$, of the reddening line on the UBV system for O9 to B1 main sequence stars is found to be $0.75 \pm 0.01$ in Cygnus, and $0.70 \pm 0.01$ in the rest of the sky. The slopes of the reddening lines are dependent on spectral class; the curvature, $\beta$, is 0.05 in both regions. On the Cape $U_cBV$ system the slope is found to be $0.37 \pm 0.01$; there is no curvature term and no significant dependence on spectral class. (auth)

**17434 EIGHT-COLOR PHOTOMETRIC STUDY OF THE ECLIPSING BINARY 44 i BOOTIS. Kurpinska, M.; van't Veer, F. (Obserwatorium Astronomiczne, Krakow. Institut d'Astrophysique, Paris). Astron. Astrophys.; 4: 253-62(Feb 1970). (In French).**

Eight-color photometric observations of the eclipsing system 44 i Bootis have been analyzed. This well known triple system is composed of an eclipsing contact binary $\beta$ and a brighter third companion $\alpha$. In the integrated light of the system $\alpha + \beta$ the observations reveal a remarkable behavior of the color-differences between the maxima and the minima. In the range $\lambda\lambda$ 4000 to 3500 both minima are redder than the maximum; in the visual wavelength region ($\lambda\lambda$ 6000 to 4000) however, a reddened maximum is found. For the other known eclipsing contact binaries showing color-differences between the maxima and minima one always finds on the contrary the minumum to be redder (up till $\Delta m = 0.05$) than the maximum in the visible color-range. (TSS) (auth)

**17435 A SEARCH FOR CLASSIFICATION CRITERIA IN SPECTRA OF K- AND M-TYPE STARS IN THE REGION $\lambda\lambda$ 5700 TO 6800 A. Gahm, G. F. (Stockholm Observatory). Astron. Astrophys.; 4: 268-79(Feb 1970).**

Slit-spectra of 33 stars of spectral types K 2-M 6, dispersion 185 Å/mm at $\lambda$ 6150 Å, have been investigated in order to obtain classification criteria with respect to spectral type and luminosity class and to study spectral features dependent on other specific properties of the stars. The criteria derived for spectral type are based on the depth and area of the TiO-depressions from $\lambda$ 6150 Å to $\lambda$ 6400 Å and the area of the TiO-depressions from $\lambda$ 6600 Å to $\lambda$ 6750 Å. Indices giving spectral type with a resolution of one spectral subdivision are discussed. Several criteria for luminosity classification have been derived from the depths of the following depressions: Ba II at $\lambda$ 6497 Å; Fe, V and Y0 at $\lambda$ 6135 Å, H$\alpha$, Na D, and the TiO bands mentioned above. The derived indices operate in limited intervals of spectral type where separation between dwarfs, giants, and supergiants is obtained. From two of the most important indices a universal index is derived operating over the entire spectral region under consideration. A tentative index separating supergiants of class Ib is also

discussed. The TiO-depression from λ 5840 Å to λ 6070 Å are shown to be of peculiar strength in some supergiants belonging to h and χ Per and I Gem. Other features with specific properties are discussed. (auth)

**17436** R–I COLOUR INDEX FOR 330 LATE TYPE STARS. Jacobsen, P.-U. (Univ. Observatory, Copenhagen). Astron. Astrophys.; 4: 302-8(Feb 1970).

The infrared color index R–I is given for 330 stars, the majority of which are G- and K-type giants brighter than 7th apparent visual magnitude. An ITT FW 118 photomultiplier with an end-on S 1 cathode cooled with dry ice was employed. The results have been transformed to R–I in Johnson's system. (auth)

**17437** PHOTOMETRIC AND ABSOLUTE ELEMENTS OF EE PEG. Catalano, S.; Rodono, M. (Univ., Catania, Italy). Astron. Astrophys.; 4: 173-9(Feb 1970).

The results obtained from photoelectric observations, especially concerning the three following points are reported: (1) the photometric period can be considered as constant disregarding the times of minima given from visual observations by Dueball and Lehmann (1965), Virkhristjuk (1964), and Marks (1962). Further observations are needed for checking the constancy of the orbital period; (2) the equatorial velocity of the primary component spectroscopically determined (Koch et al., 1963) agrees with that evaluated from the photometric elements, under the hypothesis of synchronism between revolution and rotation of such a component; (3) the absolute elements lead to the conclusion that EE Peg is one of the few detached systems with the primary component just coming out from the main sequence. (auth)

**17438** HYDROGEN-LINE EMISSION IN THE SPECTRUM OF U CEPHEI: A SEQUEL. Batten, Alan H. (Dominion Astrophysical Observatory, Victoria, B. C.). Publ. Astron. Soc. Pac.; 81: 904-6(Dec 1969).

In a recent communication (Batten and Laskarides, 1969) it was pointed out that six attempts to observe emission lines during the total eclipse of the brighter component of U Cephei had failed. A seventh attempt was successful: red-displaced emission components were observed for all hydrogen lines from Hβ to H8 on Oct. 3, 1967. (W.D.M.)

**17439** LIST OF MAGNETIC NULL LINES OF ASTROPHYSICAL INTEREST. Landstreet, John D. (Columbia Univ., New York). Publ. Astron. Soc. Pac.; 81: 896-9(Dec 1969).

A list is presented of all the lines of neutral atoms and first and second ions listed in the Revised Multiplet Table which are not split by a magnetic field. It is expected that these lines will be useful in the detailed study of atmospheric conditions in magnetic stars. (auth)

**17440** NEW FLARE STAR IN PAVO. Mumford, George S. (Tufts Univ., Medford, Mass. Cerro Tololo Inter-American Observatory, La Serena, Chile). Publ. Astron. Soc. Pac.; 81: 890-4(Dec 1969).

The star S 5114 = ·K3π 5235 Pavonis underwent a flare some two magnitudes in extent in blue light on the night of July 8, 1969. The event lasted about 15 minutes. Both spectra and color indices indicate the object to be a late-type dwarf. Hence it is likely a UV Ceti star rather than a U Geminorum variable as previously classified. (auth)

**17441** POSSIBLE OH SOURCE BC CYGNI. Gahm, G. F.; Zappala, R. R. (Univ. of California, Santa Cruz). Publ. Astron. Soc. Pac.; 81: 887-90(Dec 1969).

Observations were made that indicate that BC Cygni is a highly reddened supergiant with a normal spectrum and polarization. BC Cyg is evidently not an object of the same nature as UY Canis Majoris. (W.D.M.)

**17442** PERIOD OF THE LIGHT VARIATION OF HD 173650. Burke, E. W. Jr. (King Coll., Bristol, Tenn.); Rice, J. B.; Wehlau, W. H. Publ. Astron. Soc. Pac.; 81: 883-7(Dec 1969).

The star HD 173650 is a magnetic and spectrum variable of spectral type AOp. The photoelectric observations taken at the Univ. of Western Ontario from 1960 to 1965, and a set of observations taken at Kitt Peak in 1967 were combined in order to improve the determination of the light curve and to establish an accurate period for use in a spectroscopic study of the star. (W.D.M.)

**17443** OBSERVATIONS OF THE 5μ SOURCE IN ORION. Lee, Thomas A. (Goddard Space Flight Center, New York). Publ. Astron. Soc. Pac.; 81: 878-82(Dec. 1969).

Observations of the 5 μ source in the Orion nebula made over a two-year interval show that the source has not varied significantly in this period. The object is confirmed to be nonstellar in nature and the temperature, as suggested by the energy distribution from 2.2 μ to 5 μ, is near 650°K. (auth)

**17444** FORMATION OF PLANETARY NEBULAE. Krishna Swamy, K. S.; Stecher, T. P. (Goddard Space Flight Center, Greenbelt, Md.). Publ. Astron. Soc. Pac.; 81: 873-5(Dec 1969).

There have been a number of studies of planetary nebulae. However, very little is known about the mechanism of their formation. In particular, the mechanism by which the ejection of the material for the nebular shell arises is still open to question. So far the theoretical calculations done in one form or the other are tied up with the evolutionary processes of the central stars. These mechanisms are found to be unsatisfactory. In this note a new mechanism which is physically more plausible than the ones suggested so far is briefly discussed. (W.D.M.)

**17445** TWO NEW SOUTHERN δ SCUTI VARIABLES. Demers, Serg (Cerro Tololo Inter-American Observatory, La Serena, Chile). Publ. Astron. Soc. Pac.; 81: 861-3(Dec 1969).

Two new variables of the δ Scuti type were discovered during a search among bright southern stars. HD 9133, with a period of 66 minutes, has one of the shortest periods in its class. (auth)

**17446** INFRARED COLOR INDICES OF CARBON STARS. Bahng, J. (Northwestern Univ., Evanston, Ill. Kitt Peak National Observatory, Tucson, Ariz.). Publ. Astron. Soc. Pac.; 81: 863-6 (Dec 1969).

Infrared magnitudes of carbon stars were measured at the wavelengths of 1.2 μ(j), 1.6 μ(h), and 2.2 μ(k). The results of observations on 17 stars are listed. (W.D.M.)

**17447** SOLAR MOTION OF Ap STARS. Day, Roger W. (Univ. of Texas, Austin). Publ. Astron. Soc. Pac.; 81: 866-71 (Dec 1969).

The solar motion of Ap stars is calculated from radial velocities and proper motions, with galactic rotation effects included. The results indicate that the Ap stars are kinematically similar to normal late-B stars. (auth)

**17448** FOUR SOUTHERN PHOTOELECTRIC SEQUENCES. Fitzgerald, M. Pim (Univ. of Waterloo, Ont. Cerro Tololo Inter-American Observatory, La Serena, Chile); Wilson, W.; Stegman, J. E. Publ. Astron. Soc. Pac.; 81: 804-14(Dec 1969).

UBV photoelectric magnitudes and color indices of 104 stars in four sequences in the galactic plane are presented. They are centered at (1900 positions): $\alpha$ = 7h 51.2m, $\delta$ = –27.9°; $\alpha$ = 9h 02.0m, $\delta$ = 46.8°; $\alpha$ = 9h 13.9m, $\delta$ = –52.0°; $\alpha$ = 9h 40.7m, $\delta$ = –53.2°. The sequence stars are assigned MK classes from objective prism spectra. (auth)

**17449** AGES OF THE HYADES, PRAESEPE, AND COMA STAR CLUSTERS. van den Heuvel, E. P. J. (Univ. of California, Santa Cruz). Publ. Astron. Soc. Pac.; 81: 815-25(Dec 1969). Contract N00014-69-C-0155.

If one uses the revised $T_e$, (B–V) relations and bolometric corrections for main-sequence stars derived by Morton and Adams (1968) and Iben's evolutionary tracks for Population I stars (X = 0.71, Z = 0.02), it is found that the Hyades and Praesepe clusters are about $9 \times 10^8$ years old, while the Coma cluster has an age of about $6.5 \times 10^8$ years. (auth)

**17450** LINE-BLANKETING EFFECTS ON THE uvbyβ PHOTOMETRIC SYSTEM. McNamara, D. H.; Colton, D. J. (Brigham Young Univ., Provo, Utah). Publ. Astron. Soc. Pac.; 81: 826-33 (Dec 1969).

The equivalent-width data in the spectra of the Sun, ξ Pegasi, 50 Andromedae, and HD 19445 are used to evaluate the effect that removal of the absorption lines has on the (b–y), $m_1$, $c_1$, and β indices. The solar data, which are the most accurate, yield Δ(b–y) = –0.031m, $\Delta m_1$ = –0.189m, $\Delta c_1$ = +0.012m, and Δβ = –0.017m as the changes in the indices if all metallic lines are removed from the solar spectrum. Observations of weak-line and strong-line RR Lyrae stars indicate the $c_1$ index is nearly independent of metallic-line strength in agreement with the solar data. (auth)

**17451** PHOTOELECTRIC OBSERVATIONS OF BX DELPHINI. Basu, B. (Univ. of California, Berkeley). Publ. Astron. Soc. Pac.; 81: 834-9(Dec 1969).

BX Delphini was observed in the UBV system. The V light curve shows a hump on the descending branch in the phase region $0.2p < \phi < 0.4p$ although the hump in the B light curve is not so apparent. Similar humps in the V light curves are observed in Population II cepheids of similar period, like V527 Sagittarii and BL Herculis. The color–color diagram of BX Del lies entirely below that of the main-sequence stars, which confirms Preston's observation that BX Del is a strong-lined star with no spectral peculiarity. If the hump suggested by the V light curve should be confirmed, then

BX Del may be an extremely strong-lined example of Population II cepheids (just as SW Andromedae and AN Serpentis are extremely strong-lined examples of RR Lyrae stars). If, on the other hand, the hump observed is spurious, then Hoffmeister's classification of BX Del as the classical cepheid with the shortest known period is probably correct. (auth)

17452 ATMOSPHERIC DEPTH EFFECTS DURING RISING LIGHT OF THE 45-DAY CEPHEID, SV VULPECULAE. Grenfell, Thomas C.; Wallerstein, George (Univ. of Washington, Seattle). Publ. Astron. Soc. Pac.; 81: 732-40(Dec 1969).

Spectroscopic changes in the 45-day cepheid SV Vulpeculae in the red region of the spectrum were studied. The radial velocities of Si II can be combined with measurements of other elements to indicate that a progressive wave is seen in the atmosphere during rising light. The observations clearly show that lines formed deepest in the atmosphere are first accelerated, and that the acceleration successively affects lines formed at higher levels. The profile of Hα is complex and double, both at minimum light and again starting near maximum and lasting beyond phase 0.11. The Hα radial velocities do not fit a simple kinematic model. (auth)

17453 MOTIONS OF THE A STARS AT THE NORTH GALACTIC POLE. Eggen, Olin J. Publ. Astron. Soc. Pac.; 81: 741-53(Dec 1969).

The extensive photometric and radial velocity material for A-type stars near the NGP, collected by Perry, is discussed in light of his difficulty in deriving $K_Z$. New proper motions are derived for many of the stars. These proper motions permit a separation of young and old disk objects on the basis of their (U,V) motion. Perry's conclusion that there are two types of A stars at the NGP is shown to be the expected result from the mixture of old and young disk stars in his sample, which contains objects of types B6 to F0. The young disk stars extend to only 300 parsecs above the galactic plane and the old disk population contributes 20% of the stars to this height. Perry's sample of stars extends beyond 500 parsecs and is almost evenly divided between the two disk populations. (auth)

17454 UBV PHOTOMETRIC STUDY OF MR CYGNI. Hall, Douglas S.; Hardie, R. H. (Vanderbilt Univ., Nashville). Publ. Astron. Soc. Pac.; 81: 754-70(Dec 1969).

Photoelectric UBV observations of MR Cygni were obtained and the resulting three light curves solved. The eclipses are complete but very nearly grazing. Values of k derived six different ways (depth and shape k in three colors) agree well; the resulting elements represent all observations very faithfully. The (U−B), (B−V) indices imply a spectral type of B3 for the primary; the old classification A0 is apparently wrong. Several lines of reasoning lead to a spectral type of B8 ± 1 for the secondary. The spectroscopic orbit of Harper et al. leads to unreasonably small absolute dimensions. A mass ratio of 1.8, typical of B3 and B8 main-sequence stars, leads to 7.5 $M_\odot$, 5.1 $R_\odot$ and 4.2 $M_\odot$, 3.7 $R_\odot$ respectively. MR Cyg is probably a system of two main-sequence stars, quite close, but normal and uncomplicated. (auth)

17455 BM ORIONIS, THE ECLIPSING BINARY IN THE TRAPEZIUM. Hall, Douglas S.; Garrison, Loring M. Jr. (Vanderbilt Univ., Nashville. Kitt Peak National Observatory, Tucson, Ariz.). Publ. Astron. Soc. Pac.; 81: 771-94(Dec 1969).

Photoelectric UBV observations of BM Orionis were obtained by offsetting in a consistent manner which corrected for both nebulosity and scattered light. A complete light curve was obtained in V, with U and B observations made at maximum and minimum. (auth)

17456 LOW-ENERGY COSMIC X-RAY MEASUREMENTS. Baxter, A. J.; Wilson, B. G.; Green, D. W. (Univ. of Calgary, Alberta). Can. J. Phys.; 47: 2651-66(1 Dec 1969).

An experiment is described to investigate cosmic x rays in the energy range 0.25 to 12 keV. The data-recovery system and methods of spectral analysis are considered. Results are presented for the energy spectrum of the diffuse x-ray component and its distribution over the northern sky down to 1.6 keV with a limited extension at 0.27 keV. At the lowest energies, the flux appears to increase more rapidly and exhibits some anisotropy in arrival directions related to the gross galactic structure. Spectral characteristics of the Crab Nebula and Cygnus X-2 have also been determined. (auth)

17457 FORMATION AND GROWTH OF CARBON PARTICLES IN COOL STELLAR ATMOSPHERES. Fix, John Dekle. Bloomington, Ind.; Indiana Univ. (1969). 111p.

Thesis.

A system of differential equations is developed to describe the nucleation, growth, and evaporation of carbon particles in masses of gas undergoing changes in temperature and pressure. Solution of these equations with those describing the molecular dissociative equilibrium of the gas yield the number and size distribution of the particles present in the mass of gas at any time. In order to investigate the formation, growth, and evaporation of carbon particles in the atmospheres of cool, variable stars, numerical solutions of the equations are obtained for masses of gas having elemental abundance distributions like those of cool, variable stars. The variations of temperature and pressure undergone by masses of gas in the atmospheres of cool, variable stars are approximated by sinusoidal changes in temperature accompanied by adiabatic pressure changes. To determine whether the particles could be important in determining the structure and appearance of stellar atmospheres, the optical properties of the particles, together with their number and size distribution, are used to calculate the extinction due to the particles. (TSS) (Disser. Abstr.)

17458 STABILITY OF RELATIVISTIC SPHERICALLY SYMMETRIC STAR CLUSTERS. Ipser, James Reid. Pasadena, Calif.; California Inst. of Tech. (1969). 199p.

Thesis.

It has been suggested that very dense star clusters might play important roles in quasi-stellar sources and in the nuclei of certain galaxies, where violent events occur. Such star clusters should become unstable against relativistic gravitational collapse when, in the course of evolution, they contract down to a certain critical density. In this thesis the study of the relativistic instability which triggers such collapse is initiated: The theory of the stability of a spherically symmetric star cluster against small radial perturbations is developed within the framework of general relativity. Collisions between stars in the cluster are neglected, since in realistic situations the time scale for collisions should be much greater than the time scale for growth of the relativistic instability. The equation of motion governing the small radial perturbations of a spherical cluster is derived and is shown to be self-conjugate. Associated with the equation of motion is a dynamically conserved quantity, and a multidimensional variational principle for the normal modes of radial pulsation. The variational principle provides a necessary and sufficient criterion for the stability of the cluster. Also derived are much simpler, one-dimensional, sufficient (but not necessary) criteria for stability. The most important sufficient criterion is this: A relativistic, spherical cluster is stable against radial perturbations if the gas sphere with the same distributions of density and pressure is stable against radial perturbations with adiabatic index $\Gamma_1 = (\rho + p)p^{-1}(dp/dr)(d\rho/dr)^{-1}$. The stability criteria are used to diagnose numerically the stability of (i) clusters of identical stars with heavily truncated Maxwell–Boltzmann velocity distributions, and (ii) clusters whose densities and isotropic pressures obey polytropic laws of index 2 or 3. The calculations show that a cluster of either type is unstable against collapse if the redshift of a photon emitted from its center and received at infinity is $z_c \gtrsim 0.5$. The cluster is stable if $z_c \lesssim 0.5$. For purposes of motivation, two new theorems on the theory of the stability of highly relativistic stars (not star clusters!) are also presented in this thesis. The first theorem states that a highly relativistic, spherical star is stable if and only if its adiabatic index (assumed to be constant in the interior regions) is greater than a certain critical value, $\Gamma_{crit}$, which depends in a specified way on the high-density equation of state. Because of relativistic effects this critical value is somewhat larger than the Newtonian value $\Gamma_{crit} = 4/3$. The second theorem shows that, at high central densities, the curves of (binding energy) versus radius for certain hot, isentropic sequences of stellar models must exhibit damped clockwise spirals. This spiraling reflects the onset of instability in one radial mode of pulsation after another as the central density increases along the sequence. (Disser. Abstr.)

17459 TOTAL TRANSITION PROBABILITIES FOR THE BOWEN LEVELS OF O III. Berry, H. G.; Bickel, W. S.; Martinson, I.; Weymann, R. J.; Williams, R. E. (Univ. of Arizona, Tucson). Astrophys. Lett.; 5: 81-3(Feb 1970).

The methods of beam-foil spectroscopy were used to measure the radiative lifetimes of certain Bowen levels of $O_{III}$. In particular, the total transition probability of the $3p\ ^3S_1$ level was found to be $3.4 \times 10^8\ sec^{-1}$. This value indicates that the Bowen fluorescence mechanism is the only important process which populates the Bowen levels. (auth)

17460 EJECTION OF MASS BY RADIATION PRESSURE AND FORMATION OF PLANETARY NEBULAE. Finzi, A. (Technion, Haifa, Israel); Wolf, R. A. Astrophys. Lett.; 5: 63-6(Feb 1970).

The hydrogen-rich material forming a planetary nebula can be ejected from the contracted core of an evolved star if the luminosity is around $2 \times 10^4\ L_\odot$. Time independent models representing the light outflowing envelope that surrounds the core of the star were constructed. In the models, the rate of mass ejection is in the approximate range from $10^{21}$ g $sec^{-1}$ to $10^{23}$ g $sec^{-1}$. The velocity

at infinity of the ejected material is a few tens of km $sec^{-1}$, comparable to the observed velocities of expansion of planetary nebulae. (auth)

**17461** HAMBURG SCHMIDT-CAMERA SURVEY OF FAINT PLANETARY NEBULAE. GALACTIC ANTICENTER REGION. Kohoutek, L. (Hamburger Sternwarte, Hamburg). Bull. Astron. Inst. Czech.; 20: 307-12(1969).

The second part of the spectral Schmidt-camera survey of faint planetary nebulae contains a large area of the northern Milky Way in the direction to the galactic anticenter, $l^{II}$ 146°–214°, $b^{II} \pm 10°$. Except the 25 planetary nebulae known in this region 13 new objects were found. The appearance of half of these new nebulae is stellar in both the spectral plates and the Palomar Atlas. The measurements of nonstellar planetaries in the Palomar Atlas and the description of the spectra in the blue region of the two brightest new objects are given. The larger concentration of the new planetary nebulae toward the galactic equator indicates the approximate double average distance of these objects with respect to the known ones. Five new compact and small H II regions are described. (auth)

**17462** CONTRIBUTIONS TO THE INTERPRETATION OF THE LIGHT CURVES OF THE CLOSE BINARY SYSTEMS. III. THE LOSS OF THE LIGHT DURING THE ECLIPSES. Ureche, V. (Univ. of Cluj). Bull. Astron. Inst. Czech.; 20: 312-17(1969).

In two previous papers, the degree of accuracy up to which the close binary system components may be approximated by two nonsimilar ellipsoids (Ureche, 1969a) was analyzed, and the components projections on the plane perpendicular to the line of sight (Ureche, 1969b) were determined. In the present paper the loss of light during the eclipses of the close binary system components, within the limits of the same accuracy which was considered in Papers I and II, is calculated. (auth)

**17463** PHOTOMETRIC INVESTIGATION OF STRONG-CYANOGEN STARS. McClure, Robert D. (Yale Univ. Observatory, New Haven, Kitt Peak National Observatory, Tucson, Ariz.). Astron. J.; 75: 41-52(Feb 1970).

A cyanogen-band index which is sensitive to metallicity for late-type giant stars, but is virtually independent of surface gravity, was formed using the David Dunlap Observatory intermediate-bandpass photoelectric system. The index correlates well with logarithmic iron-to-hydrogen ratios that have been determined from curve-of-growth analysis for K-giant stars. The index is used to obtain a quantitative measure of the cyanogen anomaly for a large group of strong-cyanogen stars. These are G- and K-giants that have been previously found from spectroscopic studies to exhibit very strong cyanogen absorption. A few of the stars appear to have strong cyanogen because of a lower surface gravity than indicated by the luminosity class that has been assigned to them. The majority, however, have a true cyanogen anomaly. All stars with strong cyanogen anomalies are found to have large ultraviolet deficiencies [negative $\delta(U-B)$'s]. Interstellar color excess determined for program stars located at high northern galactic latitudes are found to be extremely low. (auth)

**17464** MAGNETIC STARS. II. OBSERVATIONS OF 56 ARI. Blanco, C.; Catalano, F. A. (Univ., Catania, Italy). Astron. J.; 75: 53-4(Feb 1970).

From the observed light curves in the U, B, V colors, no phase displacement is found in the epoch of primary minimum. Light and spectrum variations may be due to a localized active region. (auth)

**17465** THE ELLIPTICITY OF OMEGA CENTAURI DETERMINED BY EQUIDENSITOMETRY. Sistero, R. F.; Fourcade, C. R. (IMAF, Cordoba, Argentina). Astron. J.; 75: 34(Feb 1970).

Equidensitometry curves based on the Sabattier effect were obtained for the globular cluster Omega Centauri. They show elliptical flattening. Measurements of these curves give eccentricities from e = 0.42 to 0.58 at distances from the center of the cluster (semimajor axis) in the $3' < a < 8'$ range. The mean position angle of the semimajor axes is P.A. = 103 ± 6°. (auth)

**17466** SPACE DISTRIBUTION AND KINEMATICS OF LOCAL EARLY F STARS. Rydgren, A. E. (Univ. of Arizona, Tucson). Astron. J.; 75: 35-8(Feb 1970).

The apparent local concentration of early F stars within several hundred parsecs of the Sun appears to be real. It is definitely not due to a statistical fluctuation of randomly distributed stars. The theoretical calculations of other workers show that the typical age of an early F star near the main sequence is about one billion years. The galactic space motions of 96 nearby single F0–F5 stars place a maximum age of about 20 million years on the present local concentration. The reason for the apparent local concentration of early F stars is not found. (auth)

**17467** MICROTURBULENCE IN MAIN SEQUENCE STARS. Chaffee, F. H. Jr. (Univ. of Arizona, Tucson. Kitt Peak National Observatory, Tucson, Ariz.). Astron. Astrophys.; 4: 291-301(Feb 1970).

High-dispersion spectra were obtained for 23 main sequence stars in the spectral range from A 2 to G 0. Microturbulent velocities ($\xi$) were determined for each of these stars from a curve of growth analysis of approximately 90 Fe I lines in each stellar spectrum. The variation of $\xi$ with effective temperature ($T_{eff}$) is such that its mean value is 2 km/s at A 2, rises to 4 km/s in the late A stars, back to 2 km/s at F 5 and 4 km/s at G 0. It is also found that $\xi$ correlates weakly with the Strömgren $m_1$ index. The shape of the $\xi$ versus $T_{eff}$ curve can be explained by assuming a general behavior for the velocity field in and above the stellar conversion zone. (auth)

**17468** RECOMBINATION SPECTRA FROM PLANETARY NEBULAE. Van Blerkom, David Joshua. Boulder, Colo.; Univ. of Colorado (1969). 171p.

Thesis.

Recombination theory, in its customary form, treats the transfer of resonance line and continuum photons in a highly simplified manner. The radiative flux from the central star of a planetary nebula is either ignored or approximated by a black-body function over its entire spectrum. Because observations of some planetary nebulae have indicated large deviations from recombination theory of the relative intensities of lines in the visible series of H, He I, and He II, a more accurate treatment of the transfer problem is presented. (TSS) (Diss. Abstr. Int. B)

**17469** PLANETARY NEBULAE. X. Aller, Lawrence H. (Univ. of California, Los Angeles). Sky Telesc.; 39: 163-6 (Mar 1970).

The possibility that the combination variable stars, such as AG Pegasi, may be the immediate ancestors of planetary nebulae is discussed. Spectra of RW Hydrae, BF Cygni, and AG Pegasi are illustrated. (W.D.M.)

**17470** HV 13055 AS A SYMBIOTIC VARIABLE. Hodge, Paul W. (Univ. of Washington, Seattle); Wright, Frances W. Publ. Astron. Soc. Pac.; 82: 135-8(Feb 1970).

HV 13055 in the Large Magellanic Cloud has a light curve, amplitude, cycle length, and color index that are similar to those for symbiotic variables. Its known absolute magnitude ($M_B = -3.2$ at max and $-0.4$ at min) agrees with available spectroscopic evidence for galactic symbiotic stars that indicates that they are giants. (auth)

**17471** Be STARS WHICH RECENTLY SHOWED LARGE PHOTOMETRIC CHANGES. Feinstein, Alejandro (Univ. Nacional de, La Plata. Cerro Tololo Inter-American Observatory, La Serena, Chile). Publ. Astron. Soc. Pac.; 82: 132-5(Feb 1970).

Fifty stars from a list of 72 bright Be stars observed photoelectrically from 1963 to 1965 (Zeinstein 1968) were again measured during 1967 and 1968. By comparing these new observations with the last measures published, it was found that twelve of these stars show significant changes in the V and R magnitudes and/or in the (U–B) color index by more than 0.06 m. (W.D.M.)

**17472** A MASS RATIO FOR 112 HERCULIS. Seligman, Courtney E. (Univ. of California, Los Angeles). Publ. Astron. Soc. Pac.; 82: 128-31(Feb 1970).

The mass ratio of the spectroscopic binary 112 Herculis is found to be 2.06 ± 0.17. This is in good agreement with the value expected from the spectral types of the two components (B7 V and A3 V). The sharpness of the line spectra suggests that the stars are rotating synchronously with their orbital motion. (auth)

**17473** THE LIGHT VARIATION OF $\gamma$ CORONAE BOREALIS. Percy, John R. (Univ. of Toronto). Publ. Astron. Soc. Pac.; 82: 126-8(Feb 1970).

The brightness of $\gamma$ Coronae Borealis varies in both blue and yellow light by about 0.05 m in a time scale of about 0.03 d. The star appears to be a $\delta$ Scuti star. It has the earliest spectral type of any known $\delta$ Scuti star, and is the only one for which a direct determination of the mass exists. (auth)

**17474** CHEMICAL HOMOGENEITY AND ABSOLUTE MAGNITUDES OF MEMBERS OF THE HYADES AND WOLF 630 GROUPS. Eggen, O. J. Publ. Astron. Soc. Pac.; 82: 99-121(Feb 1970).

Narrow-band uvby$\beta$ photometry is used to confirm group membership of some 70 to 80% of the A- to F-type stars that were assigned to the Hyades and Wolf 630 groups using other criteria. A lower percentage of confirmation as group members among the

early type stars than previously found for the later types is not unexpected, in view of the greater reliability (for late-type stars) of spectroscopic and trigonometric parallaxes used in originally choosing group members. For stars with a range of metal abundances, measured by values of δ (U−B) up to at least 0.15 m, the divergences of main-sequence stars from the Hyades ($\beta$, $[c_1]$) relation, as well as the values of $\Delta[m_1]$ are linearly correlated with δ(U−B) at a given temperature. The chemical homogeneity of both the Hyades and Wolf 630 groups, judged by the values of $\Delta[m_1]$, for stars not obviously affected by peculiarities or luminosity effects, is comparable with that of the individual members of the Hyades, Praesepe, and Coma Berenices clusters. The peculiar F-type stars, such as $\beta$ Coronae Borealis, are not isolated in luminosity and temperature from other group stars and they may represent an evolutionary state not undergone by all stars of the same mass. (auth)

**17475** PHOTOMETRIC AND SPECTROSCOPIC OBSERVATIONS OF NOVA T PYXIDIS. Landolt, Arlo U. (Louisiana State Univ. Observatory, Baton Rogue. Cerro Tololo Inter-American Observatory, La Serena, Chile). Publ. Astron. Soc. Pac.; 82: 86-92(Feb 1970).

Photometric and spectroscopic observations obtained some two months after the December 1966 outburst of T Pyxidis are presented. (auth)

**17476** FAINT NEW WOLF–RAYET STARS IN CARINA. MacConnell, Darrell J. (Univ. of Michigan, Ann Arbor. Cerro Tololo Inter-American Observatory, La Serena, Chile); Sanduleak, N. Publ. Astron. Soc. Pac.; 82: 80-5(Feb 1970).

Nine new faint Wold−Rayet stars were found on objective-prism plates of the Carina region taken with the Curtis−Schmidt telescope at Cerro Tololo. Ultimately, these stars may help to define spiral structure in that direction at distances perhaps in excess of 10 kpc from the Sun. (auth)

**17477** OBSERVATIONS OF INTERSTELLAR SODIUM LINES IN STARS IN THE DIRECTION OF THE GALACTIC CENTER. Wallerstein, George (Univ. of Washington, Seattle). Publ. Astron. Soc. Pac.; 82: 5-9(Feb 1970).

Radial velocities and equivalent widths are presented for components of interstellar sodium in the spectra of nine stars within 20° of the galactic center. The data are compared with observations of neutral hydrogen in the direction of each star. A component at −61 km/sec in HD 160529 is discussed in some detail because it may be the first evidence from optical interstellar lines of the gas flowing out from the galactic center. (auth)

**17478** TWO INDEPENDENT PHOTOELECTRIC LIGHT CURVES AND SOLUTIONS OF W URSAE MINORIS. Devinney, Edward J. Jr. (Univ. of Pennsylvania, Philadelphia); Hall, Douglas S.; Ward, David H. Publ. Astron. Soc. Pac.; 82: 10-52(Feb 1970).

Results of two independent multicolor photoelectric studies of W UMi are presented. Good photometric elements are derived for each and found in very close agreement. All available times of minimum are examined and a new ephemeris derived. Spectroscopic complications are discussed; the range of reasonable absolute dimensions is estimated, and the primary is shown to lie above the main sequence. The (U−B), (B−V) indices indicate a spectral type for the primary of A3 ± 2, in close agreement with its known spectroscopic classifications. After correction was made for reflection, the secondary revealed an intrinsic surface brightness corresponding to a K0 (IV) star but with an untraviolet excess of $\delta_{U-B} = 1.3 \pm 0.2$ m. (auth)

**17479** SPECTROPHOTOMETRIC STUDIES OF GASEOUS NEBULAE. XV. THE HIGH-EXCITATION PLANETARY NGC 6741. Aller, L. H. (Univ. of California, Los Angeles); Krupp, E.; Czyzak, S. J. Astrophys. J.; 158: 953-7(Dec 1969).

Spectrographic data obtained at the prime focus of the Lick 120-inch telescope and photoelectric data obtained with the Cassegrain scanner at the 60-inch telescope at Mount Wilson are compared with earlier data to provide a set of line intensities for the relatively faint planetary nebula NGC 6741, which combines features of both high and low excitation. (auth)

**17480** THE ENHANCEMENT OF THE 3 $^4He \rightarrow {}^{12}C$ REACTION RATE IN DENSE MATTER BY INELASTIC-SCATTERING PROCESSES. Truran, J. W.; Kozlovsky, B.-Z. (California Inst. of Tech., Pasadena). Astrophys. J.; 158: 1021-32(Dec 1969).

The rates for the de-excitation of the 7.644-MeV ($0^+$) and 9.638-MeV ($3^-$) excited states of $^{12}C$ by neutron, proton, and $\alpha$-particle inelastic scattering are calculated as a function of temperature and density. In the absence of complete experimental information regarding these interactions, an attempt is made to assure that the estimated reaction rates provide firm lower limits. The results of these calculations indicate that, for temperatures in excess of a few billion degrees and particle densities $\gtrsim 10^6$ g cm$^{-3}$, the rates for inelastic scattering to the ground state of $^{12}C$ can exceed the rates of spontaneous radiative transitions by a significant factor. The implications of these results for astrophysical problems are discussed. (auth)

**17481** THE EARLY A STARS. IV. ANALYSIS OF THE DOUBLE-LINE SPECTROSCOPIC BINARY ETA VIRGINIS. Conti, Peter S. (Lick Observatory, Santa Cruz, Calif.). Astrophys. J.; 158: 1085-9(Dec 1969).

A detailed spectroscopic study of this binary was completed. The measured equivalent widths, corrected for the true continuum in each component, were compared with the normal A star $\theta$ Vir. The two-component stars do not have identical surface compositions. The secondary, of spectral type about A4, has deficient calcium, scandium, and titanium as in an Am star. In the primary, of spectral type A2, these elements are normal. Both stars show marginal overabundances of those heavy elements enhanced in Am stars. (auth)

**17482** THE MEAN SURFACE MAGNETIC FIELD OF $\beta$ CORONAE BOREALIS. Preston, George W. (Carnegie Institution of Washington, D. C. California Inst. of Tech., Pasadena). Astrophys. J.; 158: 1081-4(Dec 1969).

Mean surface fields of 5900 ± 120 gauss and 6100 ± 150 gauss for $\beta$ CrB were derived from resolved Zeeman patterns on high-dispersion spectrograms near the phases of positive and negative crossover, respectively. It is shown that these results are compatible with the conclusion that $\beta$ CrB is viewed at small inclination ($i \leq 20°$) and that its (hypothetical) magnetic axis lies near its rotational equator ($\beta \geq 70°$). (auth)

**17483** ON THE COLOR–MAGNITUDE DIAGRAMS OF NGC 2360 AND NGC 3680. Demarque, Pierre (Yale Univ., New Haven); Miller, Richard H. Astrophys. J.; 158: 1037-8(Dec 1969).

Eggen's recent observations of the color−magnitude diagrams of the two galactic clusters NGC 2360 and NGC 3680 are interpreted by the method previously applied to M67 and NGC 188. The width of the gap in NGC 2360 is the same as that in M67, implying similar chemical composition. The gap in NGC 3680 is significantly wider, suggesting a much higher helium abundance. NGC 3680 may be a "super-metal-rich" cluster. (auth)

**17484** HYADES RED DWARFS AND THE DISTANCE OF THE CLUSTER. Eggen, O. J. (Australian National Univ., Canberra). Astrophys. J.; 158: 1109-13(Dec 1969).

Red and infrared observations on the (R,I) system were obtained for twenty-four red dwarfs in the Hyades Cluster and twenty-five field stars of the young disk population with large trigonometric parallaxes. Proper motions of the Hyades members are available from two or more catalogs and were used to compute individual luminosities by the convergent-point method, by using the convergent point and space motions of the cluster derived from the brighter cluster members by Wayman, Symms, and Blackwell. The main sequence defined by the large parallaxes of the field stars is the same, to within less than 0.1 mag, as that obtained from the cluster members by using luminosities derived by the convergent-point method. The rms error of fit of the individual Hyades stars to the main sequence defined by the field stars is 0.2 mag, compared with the rms error of about 0.15 mag arising from errors in the proper motions. (auth)

**17485** A STUDY OF THE ECLIPSING BINARY BETA AURIGAE. Toy, Larry G. S. (Smithsonian Astrophysical Observatory, Cambridge, Mass. Harvard Coll. Observatory, Cambridge, Mass.). Astrophys. J.; 158: 1099-1107(Dec 1969).

The present study has led to the determination of the average effective temperature and surface gravity of the two components of the eclipsing binary system $\beta$ Aur. By use of photoelectric spectrum scans in conjunction with detailed abundance analyses, an effective temperature $T_{eff} = 8750°K$ and surface gravity log g = 3.7 were derived. The abundance analyses indicate similar chemical compositions for both components. Both members of this system appear to show abundance anomalies reminiscent of mild Am stars. (auth)

**17486** Ba I ABSORPTION-LINE SERIES AT HIGH RESOLUTION. Garton, W. R. S. (Imperial Coll. of Science and Tech., London); Tomkins, F. S. Astrophys. J.; 158: 1219-30(Dec 1969).

The Ba I ultraviolet absorption spectrum was reexamined at high dispersion by use of the second and third orders of the Argonne 30-foot spectrograph. The principal series $6s^2\ {}^1S_0 - 6s\ np\ {}^1P_1^\circ$ was extended to n = 75; five series previously observed by Garton and Codling (1960), ascribable to two-electron transitions and converging on $5d^2D_{3/2}$ of Ba II, have also been extended

considerably. A revised value for the first ionization potential (42035.14 ± 0.05 $cm^{-1}$) of Ba I is derived from one of these series. Configuration mixing and auto-ionization effects, revealed by the high-dispersion spectra, are discussed qualitatively. (auth)

**17487** SPECTRAL ENERGY DISTRIBUTION OF THE BARIUM STARS. Bond, Howard E.; Neff, John S. (Louisiana State Univ., Baton Rouge. Kitt Peak National Observatory, Tucson, Ariz. Univ. of Iowa, Iowa City). Astrophys. J.; 158: 1235-7(Dec 1969).

Intermediate-band photometry reveals that the Ba II stars show a broad ultraviolet absorption similar to, but weaker than, that seen in the N-type carbon stars. (auth)

**17488** THE PERIOD OF THE MAGNETIC VARIATIONS OF HD 188041. Wolff, Sidney Carne (Univ. of Hawaii, Honolulu). Astrophys. J.; 158: 1231-3(Dec 1969).

An analysis of the available observations of HD 188041 shows that the only period which will satisfactorily represent both the magnetic and spectrum variations of HD 188041 is P = 224.5d. All shorter periods have been eliminated. (auth)

## *Quasi-Stellar, Radio, and X-Ray Sources*

*Refer also to abstract 18046.*

**17489** (AD-696118) THE 21 CM ABSORPTION PROFILES OF DR 21 AND THE SOURCE NEAR NGC 6857. Thompson, A. R.; Colvin, R. S.; Hughes, M. P. (Owens Valley Radio Observatory, Pasadena, Calif.). 1969. Contract N00014-67-A-0094. 26p. CFSTI.

The 21-cm absorption profiles of two dense thermal sources, DR 21 and the source near NGC 6857 have been obtained using the interferometer at the Owens Valley Radio Observatory. DR 21 shows absorption over a range of radial velocities from +18 to -20 km/sec (with respect to the local standard of rest), although on the basis of the observed radial velocity and the usual model for galactic rotation one would not expect to find galactic clouds with negative radial velocities between the Sun and the source. The neighboring source DR 23 does not appear to show appreciable negative-velocity absorption. Three explanations for the observations of DR 21 are discussed. The radio source previously identified with NGC 6857 has been reported by Rubin and Turner (1969) to be centered 1 ft north of the nebula, at a position that coincides with the small planetary nebula K 3-50. The ionized hydrogen absorption for the source extends from +20 to -33 km/sec and a distance between 7.5 and 9.6 kpc is deduced. (auth) (USGRDR)

**17490** (AD-696119) COMPACT RADIO SOURCE IN THE NUCLEUS OF M 87. Report No. 1969-10. Cohen, M. H.; Moffet, A. T.; Shaffer, D.; Clark, B. G.; Kellermann, K. I. (Owens Valley Radio Observatory, Pasadena, Calif.). 1969. Contract N00014-67-A-0094. 9p. CFSTI.

The compact radio source in M 87 has been observed with a long-baseline interferometer composed of the 210-foot telescope at Goldstone, California, U.S.A., and the 85-foot telescope at Tidbinbilla, near Canberra, A.C.T., Australia. The observations suggest that the radio source is remarkably concentrated to the galactic nucleus and has a linear diameter of about 2.5 light months. (USGRDR)

**17491** PECULIARITIES IN QUASAR SPECTRA. Komberg, B. V. Zemlya Vselennaya; 27-30(Jul-Aug 1969). (In Russian).

A review is given on the present state of knowledge regarding quasars, taking into account a number of unusual features. Theoretical interpretation of observational data regarding quasars is discussed. A model of a quasar with nucleus containing from 1 to 100 million solar masses is described. It is pointed out that in quasar spectra the only absorption lines that could be identified were those corresponding to two, three, and five different redshifts. The observation of a shift of the absorption lines to longer wavelengths in some quasars and to shorter wavelengths in others is discussed. (IAA)

**17492** NUCLEAR FERROMAGNETISM IN NEUTRON STARS CALCULATED WITH REALISTIC FORCES. Pearson, J. M.; Saunier, Gerard (Univ. of Montreal). Phys. Rev. Lett.; 24: 325-7(16 Feb 1970).

Using a highly realistic effective interaction, it is shown that nuclear ferromagnetism in neutron-star matter is not possible for densities of $k_F < 1.8$ $fm^{-1}$. (auth)

**17493** PULSARS MAY BE NEUTRON STARS. Tilson, Seymour. IEEE (Inst. Elec. Electron. Eng.), Spectrum; 7: No. 2, 42-55(Feb 1970).

A fairly extensive review is presented on the discovery, properties, and astrophysical significance of pulsars. (W.D.M.)

**17494** APPARENT PERIODICITIES IN REDSHIFTS OF QUASI-STELLAR OBJECTS. Deeming, T. J. (Univ. of Texas, Austin). Nature (London); 225: 620-1(14 Feb 1970).

Reference is made to Cowan (Nature 224:655 (1969)) who applied the method of power spectrum analysis to the distribution of quasar redshifts and found several peaks in the power spectrum which, if real, would correspond to periodicities in the distribution. It is stated that the distribution of power levels shown by Cowan is not significantly different from that expected from the analysis of purely random noise, and it would not be surprising to find a few points corresponding to quite-high power levels in the spectrum of random noise. (UK)

**17495** LONG-PERIOD OSCILLATIONS IN ROTATING NEUTRON STARS. Ruderman, M. (Columbia Univ., New York). Nature (London); 225: 619-20(14 Feb 1970).

The structure of a rotating neutron star can theoretically support a variety of oscillations that may coexist with a couple to its surface rotation, and since it is probable that the pulsar period is kept by the rotating surface, the excitation of such modes would give small periodic modulations in observed pulsar frequencies. Most of the oscillatory modes have relatively high frequencies, but one is discussed that is unique to a rotating sphere of neutron superfluid and has a period of about 4 months, which is close to the "wobble" reported for the period of the Crab pulsar. Types of oscillations are discussed that are possible when the interior superfluid is rotating; these include the classical torsional-type oscillation of a uniformly rotating fluid, and the fluid motion that is unique to a superfluid and depends on the quantization of its microscopic motion. A rotating superfluid moves irrotationally and can mimic rigid-body rotation through a paraxial array of moving quantized vortex lines. Such a vortex array admits of two kinds of oscillations: in the first the vortex lines bend, and for wavelengths large compared with the intervortex spacing the frequencies of such oscillations are those expected for a classical fluid. The second mode of vibration of the vortex lattice consists of a purely axial movement of the vortex lines; each vortex line remains parallel to the cylinder axis but there is a redistribution of density of vortices and superfluid angular moments. The equation of motion of the vortex lattice for such motions is given, together with that for the wave velocity and the lowest admissible mode of vortex lattice motion. The oscillatory superfluid vortex mode will be coupled to the crust by two mechanisms: (a) the transfer of angular momentum directly through the crust–superfluid boundary region; (b) the interaction, throughout the entire superfluid, between the normal neutrons inside the vortex cores and the degenerate electron sea which pervades the core; this transfers angular momentum between the neutrons and the electrons and thereby to the conducting crust which is strongly coupled to the electrons by magnetic fields. Any sudden movement of the crust (on a time scale of months) will excite the slow superfluid vortex mode (as well as higher modes). The period of core rotational oscillation agrees with that reported if the neutron core is superfluid and appropriate mechanisms exist to couple it to the crust motion, and for sufficient core–crust coupling a sudden change in crust motion will excite core motions, the relative amplitude of which is less than that of the crust by the ratio of the magnetically coupled crust/electron–proton sea moment of inertia to that of the core. A small starquake may be sufficient to leave a fundamental core vortex mode oscillation of the required magnitude after other transients have been damped. A more definitive analysis should substitute spherical for cylindrical geometry, include radial density variation of neutron stars, and offer a quantitative description of core–crust coupling and damping. (UK)

**17496** LEVEL POPULATIONS OF EXCITED STATES OF HYDROGEN IN GASEOUS NEBULAE. Brocklehurst, M. (University Coll., London). Nature (London); 225: 618-19(14 Feb 1970).

The radiation from H atoms observed at radio and millimetre wavelengths and due to atomic transitions between levels of high quantum number ($n$) cannot be accounted for without accurate calculations of the population densities of all the levels, and in order to interpret the observed intensities and to deduct physical parameters such as temperatures and abundances accurate calculations of level populations are necessary. In gaseous nebulae the physical processes which may populate and depopulate a quantum level are radiative capture and cascade, collisional ionization and three-body recombination, collisional transitions ($n \rightarrow n'$) induced by electrons and protons, and radiative transitions induced by the free–free continuum within the nebula. Calculations were made for a large range of temperatures and densities and for all values of $n$, and it is claimed that these are much more accurate than any previously available. Results are tabulated. The importance of including collisional excitation and de-excitation to any level is shown. (UK)

**17497** POSSIBLE MECHANISM FOR THE PULSAR RADIO EMISSION. Komesaroff, M. M. (Commonwealth Scientific and Industrial Research Organization, Sydney). Nature (London); 225: 612-14(14 Feb 1970).

It is stated that any explanation of pulsar radio emission must take account of the fact that although a pulsar may emit highly variable individual pulses, the average properties of pulses observed at a fixed wavelength are characteristic of the pulsar. Some features of these pulses are listed. In explanation of PSR 0833-45 data it has been suggested that the radiation is sharply beamed from the vicinity of a magnetic pole and that the position angle reflects the instantaneous direction of the magnetic field lines in the emitting region. It has also been suggested that the radiation is produced by relativistic particles moving almost directly along the magnetic field lines and radiating by virtue of the acceleration associated with the curvature of these lines, in contrast with the synchrotron radiation produced by particles gyrating around the field lines. The present communication carries these suggestions a step further and an attempt is made to account quantitatively for the pulse width, polarization and spectrum of the pulses. According to the model described pulsar radiation is emitted in a hollow beam coaxial with the magnetic axis, and the pulses are produced by the motion of this beam past the line of sight as a result of rotation. The pulses are single or double depending on whether the beam merely grazes the line of sight or intersects it twice. The model provides an explanation for the observed variation of polarization position angle within the pulse and also accounts for the wavelength dependence of the component spacing in double pulses. The break in the spectrum of many pulsars can also be explained. An estimate is also permitted of the required value for the fluctuating component of particle density at the stellar surface. Almost any attempt to explain the intensity of pulsar radio emission must have recourse to the concept of coherence, that is, of large numbers of particle emitting "in phase." This implies correlated fluctuations of particle density extending over only a few cm along the line of sight. The assumption of correlated density fluctuations was introduced without physical justification, but some such assumption seems almost essential in any theory in order to account for the very intense radio emission without invoking prohibitively large numbers of radiating particles. Observations of the radio polarization of NP 0532 might provide a critical test of the model. (UK)

**17498** A SIMPLIFIED METHOD FOR CALCULATING THE INTERNAL STRUCTURE OF NEUTRON STARS. Kisdi, D. (Research Group for Theoretical Physics, Budapest). Acta Phys. Acad. Sci. Hung.; 27: 289-98(1969).

A very economical method is proposed for solution of the hydrostatic equilibrium equations of neutron stars. As a simple example the model of homogeneous internal distribution is constructed. Utilizing Brueckner's equation of state, the importance of the effect of correlation can be demonstrated. (auth)

**17499** UPPER LIMITS OF X-RAY FLUXES FROM SOME QUASARS. Brini, D.; Frontera, F.; Fuligni, F. (Univ., Bologna). Nuovo Cim.; 65B: 181-6(11 Feb 1970).

Results of two balloon flights, carrying x-ray detectors, are reported. Two sky belts centered around 44° in declination and extending from 6 h 20 min to 9 h 50 min and from 16 h 40 min to 19 h 10 min R.A. were scanned with a fairly high sensitivity in the energy range (20 to 200) keV. Upper limits of the flux from some remarkable objects, such as the Qs's 3C196, 3C186, and 3C380 are given. An emission from about 45° D and 17 h 30 min R.A. cannot be excluded. Unfortunately a latitude drift of the balloons, during flights, resulted in a general reduction of sensitivity. (auth)

**17500** OBSERVATIONS OF PULSATIONS IN THE X-RAY FLUX FROM THE CRAB NEBULA AT 2.5 AND 30 keV. Ducros, Georges; Ducros, Rene; Rocchia, Robert; Tarrius, Andre (CEN de Saclay, Gif-sur-Yvette, France). Compt. Rend., Ser. B; 269: 932-4(3 Nov 1969). (In French).

The discovery of two pulsars in the vicinity of the Crab Nebula, as well as the observation of luminous flashes with an origin in this source, led to the search for pulsations in the x-ray region. An experiment performed with a rocket in December, 1968, from the base of Kourou in French Guiana, allowed a determination to be made of the profile of the pulsation whose period is 33.0929 ms. (tr-auth)

**17501** POLARISATION OF THE RADIO PULSES FROM THE CRAB NEBULA PULSAR. Graham, D. A.; Lyne, A. G.; Smith, F. G. (Univ. of Manchester, Jodrell Bank, Eng.). Nature (London); 225: 526(7 Feb 1970).

Observations were made using a polarimeter feed in the Mark I Jodrell Bank radiotelescope at 408 MHz, and a preliminary analysis is presented for the main pulse, both in the form of an integration over many pulses and for individual pulses recorded photographically. This pulsar (NP 0532) is notoriously variable in that it occasionally produces an individual pulse very much above average, and about 1 in $10^4$ pulses is photographable on an oscilloscope. It was therefore arranged to trigger the oscilloscope only for large pulses, which were detected in a separate radio receiver tuned 2 MHz higher, so that the pulse arrived 12 ms earlier in the triggering channel, due to interstellar dispersion in pulse arrival time. Stokes parameters are shown for four individual pulses. Polarization was predominantly linear and amounted to about 70%. The position angle of the plane of polarization of the largest pulse differed by more than 60° from the angles of the smaller pulses. There was no conclusive evidence of fine structure in the pulses. Measurements made at 240 MHz showed the same high degree of linear polarization. The results are in sharp contrast to optical measurements, which show only 10 to 15% polarization, and may indicate revision of the model of Wampler et al. (Astrophys. J. Lett. 157: LI (1969)). Observations at Arecibo have shown that the integrated profile of radio pulses observed at 408 MHz and lower frequencies shows a broad precursor pulse a few ms before the sharp feature corresponding to the optical pulse. If the present recordings refer to the precursor it should be possible to describe the polarization angle as a continuous function through a considerable part of the pulsar cycle. It would then be surmised that the sharp pulse and the precursor originate in different but adjacent regions. (UK)

**17502** PULSAR NP 0532: AVERAGE POLARISATION AND DAILY VARIABILITY AT 430 MHz. Campbell, D. B.; Heiles, C. (Arecibo Observatory, Puerto Rico). Nature (London); 225: 527-8(7 Feb 1970).

Measurements of the average Stokes parameters of NP 0532 at 430 MHz were attempted. Difficulties involved are outlined; just to detect the pulsar in total intensity requires averaging over at least $10^4$ pulses, and there are large fluctuations in the total intensity of individual pulses. The observations were made in Oct. and Nov. 1969 with the 1000-ft spherical reflector and 430-MHz line feed of the Arecibo Observatory, providing two orthogonal senses of linear polarization, which were immediately combined to give the two senses of circular polarization. Details are given of the apparatus and technique adopted, and results for the Stokes parameters are shown graphically. A high degree of linear polarization was indicated, the position angle of which must have been independent of time since one of the linear Stokes parameters was zero. It was clear that the total intensity was variable from day to day in some of the pulse components. The existence of these three components in the pulse period was confirmed, and the following conclusions were drawn: (a) the precursor is essentially 100% linearly polarized over most of its width and the main pulse is about 18% linearly polarized during its rise and at its peak, and more highly polarized during its decay; the polarization of the interpulse is very weak and less than 11% at its peak; (b) the position angles of the precursor and the main pulse are the same, and the angles do not rotate within either pulse; (c) the fractional circular polarization is less than about 25, 8, and 10% for the precursor, main pulse, and interpulse, respectively; (d) the polarization properties of the precursor must be constant from pulse to pulse, since the average polarized power in one of the linear Stokes parameters is essentially equal to the total intensity. The lack of rotation of the angle of rotation in the precursor is in contrast to previous results and to the view that rotation is a general phenomenon, and the lack of rotation of the polarization angle implies that the magnetic axis and line of sight to Earth are instantaneously very closely aligned as the neutron star rotates. This implies that the precursor–main pulse combination is associated with one magnetic pole and the interpulse with the other, and therefore that the magnetic axis is nearly perpendicular to the rotation axis. The physical cause for the variations must lie in the pulsar itself rather than in interstellar scintillation, since the latter would be expected to affect all three components equally. (UK)

**17503** SIZE AND MOTION OF THE INTERSTELLAR SCINTILLATION PATTERN FROM OBSERVATIONS OF CP 1133. Lang, K. R. (Arecibo Observatory, Puerto Rico); Rickett, B. J. Nature (London); 225: 528-30(7 Feb 1970).

It was suggested that the long-term fluctuations of the intensity of pulsar radiation at radio frequencies represent scintillation caused by irregularities in the interstellar medium. Previous evidence for this hypothesis is briefly reviewed, and the present authors showed that the long-term variations of four pulsars have power spectra, modulation indices, frequency distributions, and decorrelation frequencies consistent with predictions of scintillation theory. The simplest theory is based on the assumption that the motion of the pulsar and/or interstellar medium with respect

to the Earth causes a stable diffraction pattern to be swept past a single antenna. Observations of the intensity fluctuations of CP 1133 with spaced antennae were made in an attempt to measure the scale size and motion of this diffraction pattern. These observations were made at Arecibo and Jodrell Bank in June 1969, with RH circularly polarized antennae connected to radiometers centered at 406 MHz with bandwidths of 500 kHZ and time constants of 10 ms. Pulse intensities were calculated by integrating the power with "windows" of data 100 ms wide and centered in each pulse. The autocorrelation functions and the modulation indices at the two observations were nearly identical when the effects of noise were taken into account, and the peak values of the smoothed cross-correlation functions, when corrected for noise contribution, were not significantly different from unity. From the results it is concluded that a scintillation explanation for the long-term fluctuations of CP 1133 is highly likely. Deduced parameters of the assumed stable diffraction pattern are given; the known motions of the pulsar and/or medium with respect to the Earth, differential galactic rotation, solar motion, and the Earth's rotation predict velocities well within the given range. Taking the distance of CP 1133 to be 0.15 kpc a value of $8 \times 10^4$ km is obtained for the scale size. (UK)

**17504** LONG-BASELINE INTERFEROMETER MEASUREMENTS OF CP 0329. Galt, J. A. (Dominion Radio Astrophysical Observatory, Penticton, British Columbia); Poroten, N. W.; Legg, T. H.; Locke, J. L.; Yen, J. L. Nature (London); 225: 530-1 (7 Feb 1970).

From observations of CP 0329 with an interferometer of $4.2 \times 10^8$ Å baseline at 408 MHz, an upper limit of 0.02 arc s was indicated for the size of the emitting region in position angle 93°. This is several orders of magnitude smaller than expected from current models and estimates of distance. Observations were made with the 46-m paraboloid of the Algonquin Radio Observatory and the 26-m paraboloid of the Dominion Observatory; an outline of the technique adopted is given. (UK)

**17505** EXCITATION OF SEMIFORBIDDEN $2s^2\ ^1S-2s2p\ ^3P$ LINES OBSERVED IN QUASARS AND NEBULAE. Osterbrock, D. E. (University Coll., London). J. Phys., B (London); 3: 149-60(Feb 1970).

Collisional excitation of $C^{2+}$ $2s2p\ ^3P$ by free electrons determines the strength of the λ1909 emission line observed in many quasars. Values of the collision strength for excitation of this term, and also for excitation of $2s2p\ ^1P$, are calculated for $C^{2+}$ and other members of the isoelectronic sequence from $B^+$ to $Ne^{6+}$, by solving the coupled integro-differential equations for the free-electron radial wave functions. The solutions are carried out by an iterative procedure. The averaged effect of the resonances converging on the $^1P$ threshold is taken into account through the Gallitis (1963) formula. (auth) (UK)

**17506** HIGH-ENERGY EMISSION FROM X-STARS AND PULSARS. Coppi, B. (Massachusetts Inst. of Tech., Cambridge. American Science and Engineering, Cambridge, Mass.); Ferrari, A. Lett. Nuovo Cim.; 3: 93-7(15 Jan 1970).

Very condensed stars have received increased attention recently after the identification that has been made of pulsars with stars of this type. A nonthermal mechanism for high-energy radiation and particle emission is presented which, in fact, interprets more generally x-ray sources as collapsed stars transforming rotational energy into electromagnetic radiation from the surrounding plasma. (W.D.M.)

**17507** OBSERVATIONS OF INTERSTELLAR WATER VAPOR. Turner, B. E.; Buhl, D.; Churchwell, E. B.; Mezger, P. G.; Snyder, L. E. (National Radio Astronomy Observatory, Green Bank, W. Va.). Astron. Astrophys.; 4: 165-72(Feb 1970).

A search was made for interstellar $H_2O$ emission in 53 galactic sources and for $NH_3$ in 16 galactic sources using the NRAO 140-foot telescope at 1.35 cm wavelength. Two new $H_2O$ emission sources were found, one associated with an IR star and the other with the Cygnus-1 OH emission source. Observations at high frequency resolution were made of three known $H_2O$ emission sources. Analysis of these spectra showed that the known hyperfine components are in no case present with LTE intensity distribution. (auth)

**17508** A COMPARISON OF RADIO OBSERVATIONS OF NGC 7822 (W1) WITH THE OB STARS IN THE CEPH IV ASSOCIATION Churchwell, E.; Felli, M. (National Radio Astronomy Observatory, Green Bank, W. Va.). Astron. Astrophys.; 4: 309-14(Feb 1970).

Radio maps made at 5.0 and 1.4 GHz of W 1 resolve two main components. A nonthermal contribution to the radio emission is indicated when the data at both frequencies are compared. The Lyman continuum photon fluxes of the early-type stars in the Ceph IV association are given, but the question of whether the visible O stars can fully account for the thermal emission cannot be answered until the contribution of the thermal emission is separated from that of the nonthermal component. (auth)

**17509** UBV PHOTOMETRY OF SCO-X1 DURING THE TIME OF A BALLOON OBSERVATION ON APRIL 18, 1969. Loden, L. O. (Stockholm Observatory). Astron. Astrophys.; 4: 337-8(Feb 1970).

A brief note on a photometric investigation of the object in Scorpius that is the prime suspect for the x-ray source Sco X-1 is presented. (W.D.M.)

**17510** CURVE OF GROWTH ANALYSIS OF THE ABSORPTION LINE SPECTRUM OF PHL 938. Demoulin, M. H. (Institut d'Astrophysique, Paris); Doras, N. Astron. Astrophys.; 4: 339-.40(Feb 1970).

The equivalent widths of 9 absorption lines of the quasi-stellar object PHL 938 have been measured on two spectra taken by Burbidge at the Lick 120-inch telescope. The lines are saturated. The curve of growth analysis applied to 5 lines of Fe II gives a lower limit of the number of absorbing ions in the line of sight of $3 \times 10^{13}$ $cm^{-2}$ and an upper limit of the more probable velocity of the absorbing ions of 45 km $s^{-1}$. (auth)

**17511** INTERNAL RADIAL VELOCITIES OF SOME SELECTED SMALL DIAMETER H II REGIONS. Williamson, Ray A. (Univ. of Maryland, College Park). Astrophys. Space Sci.; 6: 45-59(Jan 1970).

A photographic Fabry-Pérot interferometer was built for the University of Maryland's 20-in. telescope for the study of the radial velocities of diffuse emission nebulae. Observations of S 101, S 112, IC 5146, NGC 7380, NGC 281, and IC 1795 were made and radial velocities at many points within each nebula were determined with an estimated error of ±3 km/sec. Average heliocentric radial velocities were obtained for each nebula and they agree well with those found by other observers. For S 112 and IC 5146, a systematic difference of 6 to 8 km/sec in the radial velocities between the east and west sides of the nebulae was observed. This phenomenon is attributed to the "braking" effect of cold gas which appears to be associated with the western side of both nebulae. Ring half-widths were obtained for S 112, IC 5146, and NGC 281, and found to be consistent with expansion velocities of 5 km/sec or less. For IC 5146 the average Doppler temperature is only 5500 ± 1000 K, which indicates an even lower electron temperature. (auth)

**17512** OPTICAL VARIATIONS OF THE RADIO SOURCE 0906 + 01. Folsom, G. H.; Smith, A. G. (Univ. of Florida, Gainesville). Publ. Astron. Soc. Pac.; 81: 871-3(Dec 1969).

The light curve of 0906 + 01 for a 3-month period beginning March 10, 1969, is given. The characteristic form of the variations is strong evidence that the tentative identification of PKS 0906 + 01 as a quasar is correct. (W.D.M.)

**17513** CASSIOPEIA A ABSORPTION SPECTRUM AND THE INTERARM MEDIUM. de Jager, G. (Univ. of Manchester, Jodrell Bank, Eng.). Nature (London); 225: 622-3(14 Feb 1970).

It is stated that measurement of the neutral hydrogen absorption spectrum of the Cassiopeia A radio source can, in principle, give information about the interarm regions of the Milky Way since this source lies in, and probably on the far side of, the Perseus arm. Neutral hydrogen lying in the region between the local arm and the Perseus arm may therefore be detectable in absorption as well as in emission, and a combination of the emission and absorption data can give the spin temperature of the interarm gas. Measurements of the Cassiopeia A spectrum are described that were made with higher precision than those already published. The observations were made on August 16, 1969, with the 250-ft radio telescope, and the 256-channel digital autocorrelation spectrometer was used to measure neutral hydrogen spectra on or near the source. Results are shown graphically and discussed. An independent assessment of both the emission and absorption spectra was also made from the data obtained during observations of the Zeeman splitting of the absorption spectrum, using the Mark II telescope. It was concluded that it is possible with the present techniques to measure the interarm absorption spectrum of the source to an accuracy rather better than 1% when account is taken of all likely sources of error. (UK)

**17514** $^{18}OH$ IN SAGITTARIUS. Gardner, F. F.; McGee, R. X.; Sinclair, M. W. (CSIRO, Sydney). Astrophys. Lett.; 5: 67-71(Feb 1970).

Absorptions of the two principal $^{18}OH$ lines were measured for the sources Sgr A and Sgr B2 with an antenna beam of 12.5 arc min and a frequency resolution of 100 kHz. The abundance ratios $^{18}OH/^{16}Oh$ appear to be higher than terrestrial for the +40 km/sec

OH cloud in Sgr A and the +60 km/sec cloud in Sgr B2, and lower for the negative velocity features −130 km/sec and −90 km/sec in Sgr A and Sgr B2, respectively. The estimated natural frequencies of the $^{18}$OH lines corresponding to the 1667 and 1665 MHz lines of $^{16}$OH are 1639.47 ± 0.01 and 1637.52 ± 0.02 MHz, respectively. (auth)

**17515** LUNAR OCCULTATION OF THE GALACTIC CENTER REGION IN THE 6-CM FORMALDEHYDE LINE. Kerr, F. J.; Sandqvist, Aa. (Univ. of Maryland, College Park). Astrophys. Lett.; 5: 59-62(Feb 1970).

A lunar occultation showed that the +40 km/sec feature of the $CH_2O$ profile in the direction of the galactic center region comes from the same cloud that gives rise to the +40 km/sec components of the OH and HI absorption profiles. A more detailed $CH_2O$ absorption profile towards Sgr A, with a velocity resolution of 0.5 km/sec per channel, is also presented. (auth)

**17516** NEW OH SOURCES ASSOCIATED WITH H II REGIONS. Downes, D. (Harvard Coll. Observatory, Cambridge, Mass.). Astrophys. Lett.; 5: 53-8(Feb 1970).

Eighty galactic sources have been examined for hydroxyl lines. Two new sources have been observed in absorption and eight in emission. The absorption-line sources (G 351.6−1.2 and 28.8 + 3.5) are characterized by moderately high opacities and are believed to be molecular clouds only a few hundred pc distant. The emission-line sources lie close to galactic continuum sources (G 10.6−0.4, 20.0−0.2, 35.6−0.0, 35.6−0.4, 45.1 + 0.1, 45.5 + 0.1, 70.3 + 1.6, and 111.5 + 0.8), of which at least five are compact H II regions. Several of the emission sources display unusual satellite-line emission and the source G 35.6−0.4 may be an infrared star. (auth)

**17517** A COMPARISON OF RADIO RECOMBINATION-LINE RESULTS AND CONTINUUM SPECTRAL INDICES FOR GALACTIC SOURCES. Wilson, T. L.; Altenhoff, W. (National Radio Astronomy Observatory, Green Bank, West Va.). Astrophys. Lett.; 5: 47-51(Feb 1970).

From a comparison of the NRAO−MIT H109$\alpha$-line survey and the recent Harvard−NRAO continuum surveys, it is found that all sources which exhibit radio recombination lines have a thermal continuum spectrum. Most sources with no radio recombination line emission have steep continuum spectra, suggesting they are galactic supernova remnants; however, a small number have a flat spectrum, possibly suggesting that they are objects similar to the Crab Nebula. Within the peak flux and angular resolution limits of the surveys, it is found that at least one quarter of the source investigated is nonthermal. (auth)

**17518** MAGNETIC FUNNELING FOR ACCRETION ON NEUTRON STARS. Sofia, Sabatino (Univ. of South Florida, Tampa). Astrophys. Lett.; 5: 45-6(Feb 1970).

A funnelling mechanism is proposed which increases the efficiency of the accretion of matter onto a neutron star to such a degree that the x-ray luminosity of Scorpius X-1, for example, can be produced by a neutron star moving through an interstellar cloud, if the velocity of the star is $<10^6$ cm sec$^{-1}$, and the cloud density $>10^{-20}$ g cm$^{-3}$. By not requiring the presence of a large companion star to produce the accreting matter, this model overcomes the difficulty introduced by the low optical luminosity recently determined for the source. (auth)

**17519** ON THE TWO DISTANCE ESTIMATES TO SCO X-1. Manley, O. P. (Visidyne, Inc., Woburn, Mass.). Astrophys. Lett.; 5: 43-4(Feb 1970).

Two disparate distance estimates to Sco X-1 are discussed. It is suggested that very likely the larger of the two is correct. (auth)

**17520** LINEAR POLARIZATION AND PULSE SHAPE MEASUREMENTS ON NINE PULSARS. Komesaroff, M. M.; Morris, D.; Cooke, D. J. (CSIRO, Sydney). Astrophys. Lett.; 5: 37-41 (Feb 1970).

Average pulse shapes are given for nine pulsars while for six average linear polarization was measured. In the "double pulses" a very rapid change in the direction of polarization is found near the time of bifurcation of the pulse. Its relation to the beaming pattern of the radiation is discussed. (auth)

**17521** AN 11-CM SURVEY OF H II REGIONS LOCATED IN THE DIRECTION OF THE GALACTIC ANTICENTER. Churchwell, E.; Felli, M. (National Radio Astronomy Observatory, Green Bank, W. Va.). Astron. J.; 75: 69-70(Feb 1970).

Thirty-five of the H II regions listed in Sharpless' catalogue (1959) lying between 120 and 230° of galactic longitude were observed at a wavelength of 11.1 cm. Of these, only 14 were definitely detected. The peak positions, half-power widths, peak antenna temperatures, and flux densities are given for the detected sources. (auth)

**17522** FLUX MEASUREMENTS OF RADIO SOURCES AT 2695 MHz. Ames, Susan (Univ. of California, Berkeley). Astron. J.; 75: 71-5(Feb 1970).

The flux was measured at 2695 MHz of the radio sources in a 5000-MHz survey. The spectral indices between these frequencies are found, and their distribution shows an excess of flat spectra. Approximately one-third of the sources appear to have convex spectra at these higher frequencies. (auth)

**17523** DISTRIBUTION OF QUASISTELLAR RADIO SOURCES ON THE SKY. Arp, Halton (Carnegie Institution of Washington, D. C. California Inst. of Tech., Pasadena). Astron. J.; 75: 1-12(Feb 1970).

All QSR's currently known that have measured redshifts are analyzed as a function of their apparent magnitude V. It is shown that a minimum of 40% of the intermediate-brightness QSR's ($16.2 \leq V \leq 17.0$ mag) form pairs which are separated by from 4 to 13° on the sky. This precludes the possibility that these QSR's can be at the great distances given by the usual assumption that they obey the galaxy redshift−distance relation. These intermediate-brightness QSR's seem instead to be associated with very bright galaxies, such as M81, NGC 1068, and the Virgo Cluster. Faint QSR's ($V > 17.0$ mag) are shown to be distributed on the sky in the same characteristic way that slightly less bright galaxies are distributed ($9.0 \lesssim m_{pg} \lesssim 12.5$ mag). Computer analysis demonstrates that these faint QSR's fall much closer to galaxies in this magnitude range than could randomly positioned QSR's. Statistically significant alignment of the nearest QSR's across just those galaxies with the most strongly correlated distances is also demonstrated. The most conspicuous grouping of faint QSR's in the sample is shown to be associated with the exploding galaxy NGC 520. The four faint QSR's in this region lie with extreme accuracy along a previously established ejection line from NGC 520. Similarity of redshifts further demonstrates the physical reality of the association, and the behavior of radio fluxes and indices agree with previously published relationships for ejected radio sources. Evidence that the highest redshifts are associated with low intrinsic luminosities is used to explain the cutoff in numbers of QSR's with $z \gtrsim 2$ and the anomalous distribution of high-redshift QSR's first pointed out by Strittmatter et al. Finally, the brightest QSR's are indicated to be, for the most part, associated with M31 and the Local Group of galaxies. (auth)

**17524** PULSAR NP-0532—A SPECTROSCOPIC BINARY? Dart III, Henry P. Spectrosc. Lett.; 2: No. 2, 31-5(Feb 1969).

The change of period for NP 0532 for the period Oct. 20 to Dec. 9, 1968 is shown. The changing period, coupled to the fact that NP 0532 has an optical source, leads to the conclusion that NP 0532 is a member of a spectroscopic binary system. The significance of this conclusion is briefly discussed. (W.D.M.)

**17525** PULSAR PERIODS AND KEPLER'S THIRD LAW. Poss, H. L. (Temple Univ., Philadelphia). Amer. J. Phys.; 38: 109-10(Jan 1970).

The periods of currently known pulsars range from $3.3 \times 10^{-2}$ to 3.5 sec. If it is assumed that the nature of these objects is such that their periods are direct measures of their rotational frequencies, then it is possible to demonstrate in a simple way that pulsars are probably superdense bodies. (W.D.M.)

**17526** THE 21-CM ABSORPTION PROFILES OF DR 21 AND THE SOURCE NEAR NGC 6857. Thompson, A. R.; Colvin, R. S.; Hughes, M. P. (Stanford Univ., Calif.). Astrophys. J.; 158: 939-51(Dec 1969).

The 21-cm absorption profiles of two dense thermal sources, DR 21 and the source near NGC 6857, were obtained by using the interferometer at the Owens Valley Radio Observatory. DR 21 shows absorption over a range of radial velocities from +18 to −20 km sec$^{-1}$ (with respect to the local standard of rest), although on the basis of the observed radial velocity and the usual model for galactic rotation one would not expect to find galactic clouds with negative radial velocities between the Sun and the source. The neighboring source DR 23 does not appear to show appreciable negative-velocity absorption. Three explanations for the observations of DR 21 are discussed: (1) DR 21 is located at a distance of 5.5 kpc, it is not associated with DR 23, and it has a component of radial velocity of 25 km sec$^{-1}$ in addition to the galactic orbital motion to be expected at its location; (2) DR 21 is located at a distance of ≤3 kpc, and galactic clouds with peculiar-velocity components of −20 km sec$^{-1}$ occur within the line of sight to the source; (3) DR 21 is located at a distance of ≤3 kpc, and the H I gas immediately surrounding it is moving outward at a velocity equal to the expansion velocity of the H II region. This last pos-

sibility is discussed with reference to a thin, high-velocity shell of neutral gas predicted by theoretical studies of the development of H II regions. The radio source previously identified with NGC 6857 has been reported by Rubin and Turner to be centered 1′ north of the nebula, at a position that coincides with the small planetary nebula K3−50. The H I absorption for the source extends from +20 to −33 km $sec^{-1}$, and a distance between 7.5 and 9.6 kpc is deduced. (auth)

## Solar Phenomena

*Refer also to abstract 17718.*

**17527** THE SUN AND INTEPLANETARY SPACE. SOLAR ACTIVITY AND FLARE FORECASTING. Takenoshita, Yugoro (Radio Res. Lab., [Tokyo]). Denpa Kenkyusho Kiho; 15: 147-56(May 1969). (In Japanese).

Flare forecasting is discussed, based on various associated phenomena on the solar surface (appearance of sunspot group, active regions). General structure of the solar atmosphere is described first. Development of the active region, which begins with appearance of faculae and plages, then develops into sunspot groups accompanied by flares in the chromosphere, and ends with the reduction of the spot, is discussed using recent observational data. Detailed observational data on the flare are reviewed. A theory of Sturrock and Copi, in which the flare eruption is mainly due to gravitational resistive instability, is described. Flare forecasting based on the statistics by Giovanelli is discussed. Relation of proton flares to the δ configuration of the magnetic field on the spot was pointed out by Warwick. Precursors in radio-emission at wavelength ~0.1 to 10 cm is discussed. Typical observations are illustrated to show these features. (NSA of Japan)

**17528** DIFFERENTIAL TERM DISPLACEMENTS IN SPECTRA OF FeI, TiI, AND NiI. Prokof'ev, V. K.; Terez, G. A. Izv. Krym. Astrofiz. Observ.; 39: 170-85(1969). (In Russian).

Term displacements in spectra of Fe I, Ti I, and Ni I in the discharge at atmospheric pressure and the lower one are considered. The large sensitivity to the displacements of the terms of higher multiplicity determined by Babcock is confirmed. It is found that the dependence of displacements in the term energy for Fe I and Ti I is submitted to one quadratic dependence in the case of the consideration of the term energy with respect to the energy of atom ionization. (auth)

**17529** THE STRUCTURE AND DEVELOPMENT OF A SUN-SPOT GROUP ON JULY 4–8, 1966. Steshenko, N. V. Izv. Krym. Astrofiz. Observ.; 39: 245-52(1969). (In Russian).

The structural peculiarities of a sunspot group in the process of its growth are investigated on the basis of photoheliograms, obtained with high resolution. The group is characterized by the complex structure and rapid change of the umbrae of sunspots. Comparison of the disposition of penumbra filaments with maps of the transverse magnetic field, obtained by Severnyi and Tsap shows, on the whole, a good agreement in the orientation of filaments and the field. It is an additional confirmation of the fact that the investigation of the fine structure of spots from direct photographs of the Sun can give the additional information on the structure and evolution of the strong magnetic field. (auth)

**17530** DETERMINATION OF THE MAGNETIC FIELD STRENGTH FROM DIFFERENT ABSORPTION LINES. Guseinov, M. Dzh. Izv. Krym. Astrofiz. Observ.; 39: 253-64(1969). (In Russian).

On the basis of spectrograms, obtained with the echelle spectrograph of the tower solar telescope of the Crimean astrophysical observatory, the absolute values of the magnetic field strength H are determined from different absorption lines. It is found, that the magnetic field strength changes from one line to another and depends both on the Rowland intensity and on the excitation potential of the lower level of the line. There is a dependence between H and mean optical depths $\bar{\tau}$ of lines. The field is very inhomogeneous with depth and H increases, in the main, with the increase of $\bar{\tau}$. But in a separate case, there were both positive and negative gradients of the field into the depth of a spot. It has been determined that in the period from September 2 up to September 5, 1961, in the spot-leader of group No. 251 the coming up to the surface of the magnetic field took place. (auth)

**17531** PHOTOSPHERIC AND CHROMOSPHERIC MAGNETIC FIELDS AND THE BRIGHTNESS OF FACULAE AND FLOCCULI. Tsap, T. T. Izv. Krym. Astrofiz. Observ.; 39: 265-75(1969). (In Russian).

Photospheric and chromospheric longitudinal magnetic fields and the brightness of faculae and flocculi are compared. The relation between the brightness distributions at different depths in active regions on the Sun is investigated. The following results are obtained: (1) There is a close relation between the position of faculae, observed in the light of lines 5250 and 6102.7λ and flocculi, observed in lines of $K_3$ $Ca^+$ and core $H_\alpha$ and the position of the photospheric and chromospheric magnetic field. (2) Correlation coefficients of the brightness of flocculi in $K_3$ and core $H_\alpha$ with both photospheric and chromospheric magnetic fields are approximately equal. (3) The course of the brightness change in the case of the section through the active region in lines 5250λ, 6102.7λ, $K_3$, and core $H_\alpha$ is approximately equal, though sometimes there are small deviations. Results agree well with the fact that distributions of the magnetic field in the photosphere and chromosphere are close. (auth)

**17532** MAGNETIC FIELD OF THE SOLAR PROMINENCE. Kotov, V. A. Izv. Krym. Astrofiz. Observ.; 39: 276-8(1969). (In Russian).

Results of the measurement of the longitudinal magnetic field in the prominence from $H_\alpha$ lines made with the help of the solar magnetograph of the Crimean astrophysical observatory are given. The magnetic field of separate elements is ~100 G. (auth)

**17533** STUDY OF SPECTROHELIOGRAMS IN METAL LINES AND THE CHROMOSPHERE STRUCTURE. Dubov, E. E. Izv. Krym. Astrofiz. Observ.; 39: 279-94(1969). (In Russian).

Distributions of bright and dark parts of spectroheliograms obtained in metal lines (Fe I 4202 Å, 4384 Å, Ca I 4227 Å, Sr II 4078 Å, NaI 5890 Å, and $K_3$ Ca II) at different distances from line centers, are compared. It is concluded that these brightness distributions do not contradict the ideas on the chromosphere structure developed previously. Brightness distributions on spectroheliograms in metal lines reflect mainly the structure of velocity fields in the photosphere and the distribution of photospheric faculae in active regions. Ascending motions (except $D_2$ line Na I) are observed mostly near boundaries of supergranules. The stronger the line, the greater is the influence of atmospheric structure on the brightness distribution on a respective spectroheliogram. In the Na I 5890 Å line, this influence is expressed more clearly. Near boundaries of supergranulae in this line the lighter material (as in $H_\alpha$) is observed more often. Taking into account the brightness distributions on spectroheliograms obtained in the line of ionized strontium, 4078 Å, one can suppose that both the comparatively deep layers of the photosphere and the sufficiently high chromosphere layer take part in the formation of the emission revealed in this line. (auth)

**17534** TURBULENCE IN QUIESCENT PROMINENCES AND SHOCK WAVES IN THE UPPER ATMOSPHERE. Dubov, E. E. Izv. Krym. Astrofiz. Observ.; 39: 295-8(1969). (In Russian).

It is shown that shock waves, penetrating into a prominence, may support the turbulence in quiescent prominences. (auth)

**17535** ON THE ROLE OF THE COMPRESSION AND EXPANSION OF THE GENERATION REGION IN THE SYNCHROTRON RADIOEMISSION. Gopasyuk, S. I.; Eryushev, N. N.; Neshpor, Yu. I. Izv. Krym. Astrofiz. Observ.; 39: 299-316(1969). (In Russian).

Data on pulse-type bursts in the centimeter range during solar flares are analyzed. It is shown that explanation of the decreasing phase of these bursts as occurring only by ionization losses meets with difficulties. The problem on the time variation of the synchrotron flux density of relativistic electrons with the power-law spectrum, taking into account the ionization losses, is considered. It is supposed that the generation region of this emission experiences originally the homogeneous compression and then expansion. Velocity of the compression and expansion is taken as constant. It is shown that, in the case of compression, the flux density at the given frequency increases in proportion to the value of the compression in the power law of the initial differential energy spectrum of relativistic electrons. To a considerable extent, ionization losses decrease the flux density. In the case of expansion, on the contrary, the flux density in due course decreases, depending on the degree of expansion, ionization losses, and the power index of the differential spectrum according to the same law as in the case of the compression. The results are applied for the explanation of increasing and decreasing parts of pulsed bursts. Bursts of the pulse type are best described with conditions of small losses. Such a description of the observing time variation of bursts allows estimation of both parameters of the radiating region and parameters of the differential energy spectrum of relativistic electrons. Besides that, the total number of electrons radiating at a given frequency, is determined. Values of all obtained parameters are in full accordance with the modern ideas on the radiating region and energy spectrum of relativistic electrons. (auth)

**17536** DEPTHS OF THE FORMATION OF SOME ABSORPTION LINES IN THE SOLAR ATMOSPHERE. Buslavskii, V. G. Izv. Krym. Astrofiz. Observ.; 39: 317-24(1969). (In Russian).

Effective depths of the formation of absorption lines in the solar atmosphere, used for recording of the magnetic field with the double magnetograph of the Crimean astrophysical observatory (λλ4808, 5250, 5302, (Fe I), λ6103 (Ca I), and λ4554 (Ba II)) were determined. (auth)

**17537** THE CATALOGUE OF UNUSUAL PHENOMENA IN THE SOLAR RADIOEMISSION AT THE FREQUENCY OF 208 MHz DURING IGY AND IQSY. Moiseev, I. G.; Yurovskaya, L. I.; Yurovskii, Yu. F. Izv. Krym. Astrofiz. Observ.; 39: 325-537 (1969). (In Russian).

The catalog contains 622 bursts of solar radiation (208 MHz), recorded at the Crimean astrophysical observatory during IGY and IQSY from July 1957 to December 1959. Bursts are represented as copies from original recordings of the general solar radio flux. (auth)

**17538** OSCILLATOR STRENGTHS FOR Ti I SPECTRA. Prokof'ev, V. K.; Ratobyl'skaya, T. A. Izv. Krym. Astrofiz. Observ.; 39: 186-231(1969). (In Russian).

Measurements and calculations of relative values of oscillator strengths in Ti I spectra, available in the literature, are revised critically. A summary of recommended values for 737 lines, belonging to 255 multiplets, is compiled. The formula of the transition from relative values, given in the King scale, to absolute, is determined. (auth)

**17539** ABUNDANCE OF IRON IN THE SOLAR PHOTOSPHERE. Ross, J. E. (Univ. of California, Los Angeles). Nature (London); 225: 610-11(14 Feb 1970).

It is stated that recent measurements of f values for solar Fe indicate systematic errors in the f values of transitions arising from high upper levels in earlier f-value compilations. Application of the new f values in a curve of growth analysis yields a solar Fe abundance log $[N(Fe)/N(H)] + 12 = \{Fe\} = 7.5$, in agreement with coronal and meteoric determinations. Previous authors used total intensities of the lines and ignored information given by the shape or profile of the line. The present paper emphasises the importance of the line profile in abundance analysis. On this basis older f values should be increased by a factor of 5. This increase is partially offset if account is taken of the damping constant, affecting the equivalent widths of medium strength to strong (saturated) lines. The chief contribution to the damping constant of a neutral Fe line in the solar photosphere arises from collisions with neutral H atoms. The photospheric Fe abundance must be considered uncertain until reliable damping constants are obtained for lines having reliable f values, or until reliable f values for weak lines are found. The present analysis indicates, however, that $\{Fe\} = 7.2$ should be considered an upper bound based on the newer f values. (UK)

**17540** SOME EFFECTS OF THE SOLAR WIND. Conforto, A. M. (Univ., Rome. CNR, Rome). Nuovo Cim.; 65B: 208-20 (11 Feb 1970).

Correlations of solar wind with geomagnetic activity are examined, in the attempt to disentangle the most effective parameters and to investigate whether magnitude or variability is more important. The IMP-1 observations were used; in particular, the plasma data were the revised values as obtained from the curve-fitting method of Olbert and Moreno. Also, the relation between solar wind and daily variations of cosmic rays is investigated. Comparison with the results of previous statistical studies is made; but no clear answers to any of the related problems are found. (auth)

**17541** COSMIC RAYS AND THE ORIGIN OF THE SOLAR SYSTEM. Prentice, A. J. R.; ter Haar, D. (Oxford Univ.). Acta Phys. Acad. Sci. Hung.; 27: 231-5(1969).

It is shown that cosmic rays may have caused sufficient ionization in a solar disc in a Kant–von Weizsäcker type of theory about the origin of the solar system to produce a conductivity high enough for magnetohydrodynamic effects to be important. (auth)

**17542** DOUBLE-$K_2$ EMISSION LINE OBSERVED IN SUNSPOTS AND IN PROMINENCES. Engvold, O. (Inst. for Theoretical Astrophysics, Oslo); Livingston, W. Publ. Astron. Soc. Pac.; 81: 795-803(Dec 1969).

The narrow- and double-$K_2$ emission lines frequently observed in spectra of sunspots are most likely emitted by quiescent-type prominences pointing into the spots. (auth)

**17543** CORONAL ENHANCEMENTS: TEMPERATURE AND DENSITIES FROM RADIO EMISSION. Leblanc, Y. (Observatoire, Meudon, France). Astron. Astrophys.; 4: 315-30(Feb 1970). (In French).

Radio coronal enhancements (S-Component centers) were observed with the east–west interferometer at Nançay at a frequency of 169 MHz, during all the last solar cycle (1957–1968). The main properties of these enhancements were deduced. The electron density and temperature of these radio enhancements are higher than those of the "quiet sun." It is shown that from the thermal emission of an active center, one may deduce its electron density if it is on the limb, and its temperature if it is near the solar meridian. A model of coronal enhancement is found which, superposed on an oblate ellipsoidal corona gives a brightness distribution compatible with the observations; the typical electron temperature is $1.8\ 10^{6}$°K, and the electron density three times the background. These results are in good agreement with those derived from the optical emission of coronal enhancements (spectroscopic and polarimetric observations). The effect of the refraction at 169 MHz has been computed for different heliographic longitudes of the coronal enhancement. A comparison is made between the characteristics of radio and optical coronal enhancements: they appear to be associated with the same region. A similar conclusion is obtained when the correlation of the occurrence of optical and radio enhancements observed on the same limb is studied. (auth)

**17544** RADIATIVE RELAXATION OF CHROMOSPHERIC OSCILLATIONS. Stix, M. (Max-Planck-Institut fuer Physik und Astrophysik, Munich). Astron. Astrophys.; 4: 189-201(Feb 1970).

The problem of radiative relaxation of oscillations generated by a granule is studied. The atmosphere is assumed isothermal and the equations of motion are linearized. As in the work of Meyer and Schmidt (1967), the granule is described by a rotationally symmetric motion of the lower boundary of the atmosphere. The variation of the characteristic radiative relaxation time with height is treated in a three layer model atmosphere. The radiative decay time $\tau_R$ is assumed to be constant within each layer. Four types of eigenmodes occur in such a model: 1. modified sound waves; 2. pure horizontal sound waves; 3. surface gravity waves; 4. internal gravity waves. Whereas types 1 and 4 show an appreciable damping, types 2 and 3 are almost unaffected by radiative relaxation. Internal gravity waves may exist only if $\tau_R > 1/2$ N, where N is the Väisälä–Brunt frequency. The results may be summarized as follows: a single granule can excite the atmosphere to oscillations lasting 3 to 4 pulsation periods in an area of ca. 3" to 6" in diameter. Concerning such oscillations one finds agreement with observations in variation of amplitude, frequency spectrum, and phase relations of the velocity as well as in amplitude and phase of the temperature fluctuation. However, the model fails to explain oscillations of longer lifetime and larger size, which seem to need to be maintained by a different energy source. (auth)

**17545** CONTINUUM INFRARED RADIATION OF THE SOLAR PHOTOSPHERE. Lena, P. (Observatoire, Meudon, France. Univ., Paris). Astron. Astrophys.; 4: 202-19(Feb 1970). (In French).

A high spatial resolution image scanner (accuracy better than 1"), coupled with suitable interference and/or reststrahlen filters and a fast helium cooled Ge-Bolometer (NEP = $3 \times 10^{-13}$ W $Hz^{-\frac{1}{2}}$) has been mounted on the 150 cm MacMath Solar Telescope. Using the full advantage of the dry site, the center to limb variation of the solar brightness has been measured on the Sun's disc at wavelengths of 5, 10, and 20 microns from the center of the disc to 2" from the limb ($\mu > 0.06$). Data collection and reduction have been considerably improved over the previous results (Léna, 1968) and serious gains in resolving power and in signal to noise ratio have been achieved. Effects of atmospheric transmission fluctuations are minimized by using fast scans and numerous averages of individual scans. Final S/N ratio amounts to about 100. The 2" resolution is achieved despite smearing effects of the order of 4", by the use of the proper deconvolution technique: two dimensional Fourier transforms reduce to very convenient Hankel transforms in this circular symmetry case. The atmospheric image degradation in the infrared and its chromatic dependence is briefly mentioned; scattering is shown to be negligible at the wavelengths beyond 5 microns. (auth)

**17546** SOLAR CORONA, INTERPLANETARY PLASMA, AND PROMINENCES. Unsoeld, A. (Univ., Kiel). Astron. Astrophys.; 4: 220-8(Feb 1970).

The structure and dynamics of the solar corona and the interplanetary plasma are reviewed. The Bernoulli equation and the equation of continuity are discussed, as well as the equation of state and the equation connecting the temperature T with either the distance from the Sun r or the density $\rho$. Two introductory sections describe simple graphical solutions for static models, with T(r) either constant or determined by heat conduction. Dynamical models can exhibit either accretion or solar wind, i.e., inflow or outflow. The velocity of the solar wind near the Earth

can be calculated using the Bernoulli equation only from the measured temperatures and densities near the Sun and near the Earth. Accretion would be obtained, for example, if the temperature of the corona were <480,000°K or if the corona were adiabatic. A polytropic model with $T \sim \rho^{0.11}$ (reproducing the observed temperature distribution) must involve a mode of energy transfer which is not influenced by the field of gravitation (e.g., conduction). Using the equation of continuity and the observed density distribution of the corona, the velocity of the solar wind is calculated as a function of r. The solar wind can exist only because thermal energy from the corona is carried far outwards from the Sun by conduction. Otherwise the outflowing matter could not overcome the gravitational attraction of the Sun. Prominences are cool clouds in the corona. Their direction of motion is mostly governed by magnetic fields. Along the field lines they are mostly dragged by the surrounding corona, whose streaming is due to horizontal pressure differences in the lower corona produced by unequal "wave-heating." Due to the enormous viscosity of the coronal plasma and the filamentary structure of prominences, their motion is largely laminar. The apparent weightlessness of prominences and their similarity to terrestrial clouds are explained in the same way. (auth)

**17547** EXPERIMENTAL OSCILLATOR STRENGTHS OF Fe II LINES AND THE SOLAR IRON ABUNDANCE. Baschek, B. (Univ., Heidelberg); Garz, T.; Holweger, H.; Richter, J. Astron. Astrophys.; 4: 229-33(Feb 1970). (In German).

The wall-stabilized arc burning in argon with a small admixture of iron chloride used by Garz and Kock (1969) to measure oscillator strengths of Fe I lines also allows the determination of oscillator strengths of Fe II lines. Oscillator strengths of 14 Fe II lines based on the absolute scale of Garz and Kock for Fe I lines are presented. A solar abundance $\log \epsilon$ (Fe) = 7.63 ± 0.20, normalized to $\log \epsilon$ (H) = 12.00, is derived out of ionized iron lines. A comparison with previous experimental and stellar oscillator strengths of Fe II lines is carried out and some implications on analyses of stellar spectra are discussed. (auth)

**17548** RELAXATION TIME OF TEMPERATURE PERTURBATIONS IN THE PHOTOSPHERE. Schmieder, Brigitte (Observatoire, Meudon, France). Compt. Rend., Ser. B; 269: 935-7(3 Nov 1969). (In French).

A study was made of the variations in density and temperature associated with an oscillatory component, of period 5 mn, of the microscopic velocity field. Measurements of the phase difference and the relation of the amplitude between the velocity fluctuations allows an estimation of the atmospheric relaxation time as 500 s. (J.F.P.)

**17549** INTRODUCTION TO THE SOLAR WIND. Brandt, John C. A Series of Books in Astronomy and Astrophysics. San Francisco, W. H. Freeman and Company (1970). 209p. $10.00.

Written at an intermediate level, this book covers all aspects from the stellar structure required to produce an extended atmospheric envelope, or corona, to the impact of the solar wind on the bodies of the solar system and the influence of stellar winds on stellar structure and evolution. All methods of observation are presented, although emphasis is on broad principles, which are treated as an integral and natural part of solar physics and astronomy. (TSS)

**17550** MAGNETIC FIELDS ASSOCIATED WITH SOLAR-ACTIVE-REGION PROMINENCES. Harvey, John Warren. Boulder, Colo.; Univ. of Colorado (1969). 331p.

Thesis.

An observational study of the magnetic fields in and around active region prominences is presented. The principal observational data consisted of about 200 measurements of the longitudinal magnetic field in active region prominences made with the High Altitude Observatory magnetograph using the H-$\alpha$ line. Observations of the longitudinal magnetic field of the chromosphere on the disk and the corona above active regions were also secured. The theory and practice of the measurements are discussed as well as recent modifications to the magnetograph. Noise sources were investigated. An attempt to achieve better spatial resolution was made by using photographic techniques at the Lockheed Solar Observatory. The reduction technique and theory of these observations are described. The distribution of the photospheric total magnetic field vector in several active regions was observed with the Kitt Peak National Observatory magnetograph. The operational principles of the instrument, an empirical calibration of the transverse field measurements and the reduction of the measurements are described. Methods for computing potential magnetic fields above active regions are discussed. Efforts to compute approximate force-free field configurations are outlined. The potential field methods were applied to the observations and to data furnished by Mt. Wilson Observatory. (TSS) (Diss. Abstr. Int., B)

**17551** SOLAR LIMB DARKENING IN THE FAR INFRARED AND ITS RELATION TO THE TEMPERATURE OF THE CHROMOSPHERE. Mankin, William Gray. Baltimore; Johns Hopkins Univ. (1969). 179p.

Thesis.

A balloon-borne telescope and filter radiometer were used to observe the limb darkening of the Sun at six infrared wavelengths ranging from 11 to 115 $\mu$ in order to determine the variation of electron temperature with height in the lower chromosphere. The balloon-borne instrument, consisting of a stabilized platform, a 38-cm Newtonian telescope, and a filter radiometer is described in detail. The two-channel radiometer employs reststrahlen filters and focal isolation techniques for selecting the far infrared radiation observed. Details of the tests and calibrations as well as circumstances of the flight are given. The corrected limb-darkening curves are converted into a spectrum and the results compared with those of other investigators and with the predictions of the Bilderberg Continuum Atmosphere. In general, the results are in accord with the other experimental results, which may be directly compared. The results are also in accord with the predictions of the Bilderberg model for wavelengths less than 70 $\mu$ but in serious disagreement at longer wavelengths. The present results show a sharp decline in the solar brightness temperature from 80 to 120 $\mu$ in contrast with the Bilderberg model which predicts a slight increase in this region. On the basis of the limb darkening measurements, an approximate model of the lower chromosphere is constructed. It is characterized by close agreement with the Bilderberg model for $\tau_5 > 1.4 \times 10^{-3}$, with a temperature plateau near 4650° in the vicinity of $\tau_5 = 2-10 \times 10^{-3}$. Above this point there is a sharp gradient to a temperature of 4000° near $\tau_5 = 6 \times 10^{-4}$, followed by a nearly isothermal region. (Diss. Abstr. Int., B)

**17552** HELIUM IN THE SOLAR WIND. Robbins, D. E. (Univ. of Houston, Tex. Manned Spacecraft Center, Houston, Tex.); Hundhausen, A. J.; Bame, S. J. J. Geophys. Res.; 75: 1178-87(1 Mar 1970).

Data obtained from electrostatic analyzers on the Vela 3A and 3B satellites from July 1965 to July 1967 have been analyzed to obtain relative helium abundances and plasma properties. Ninety percent of the 10,314 spectra used from this period gave helium to hydrogen density ratios from 0.01 to 0.08. The long term average was 0.037, which is lower than the recently reported solar-surface ratio of approximately 0.063. For the time period covered in this analysis, only 10% of the spectra yielded helium to hydrogen density ratios greater than 0.063. Large variations in the helium to hydrogen density ratio were observed even when averaged over a solar rotation. Sudden increases in the solar wind helium content followed simultaneous occurrences of Forbush decreases and sudden-commencement geomagnetic storms. The magnitude of the helium to hydrogen density ratio, however, was not correlated to the magnitude of the geomagnetic storm, as measured by the Kp index. The ratio of the helium to hydrogen velocities was strongly peaked around 1.0, as might be expected. The distribution of the helium to hydrogen temperature ratios had a full width at half maximum of approximately 2.5 and a mean of approximately 4.0. (auth)

**17553** A SMALL SOLAR X-RAY FLARE ON AUGUST 17, 1966. Horstman, H. M. (Goddard Space Flight Center, Greenbelt, Md.); Moretti, F. Horstman. J. Geophys. Res.; 75: 1157-62(1 Mar 1970).

A detector sensitive to x rays in the 7- to 50-keV range was flown on a rocket on August 17, 1966. An increase in counting rate, lasting from 19:56:05 to 19:57:20 GMT, was observed from a region of sky that contained the sun. No particular solar activity was reported for that time, but a solar flare, possibly in the region of the limb, appears to be the most likely explanation. The corresponding energy output in the 7.6- to 27.2-keV region was approximately $10^{-7}$ ergs $cm^{-2}$ $sec^{-1}$. The sun was observed during the rest of the flight but was not detected, yielding an upper limit for the quiet sun of 0.015 photons $cm^{-2}$ $sec^{-1}$ $keV^{-1}$ in the 10- to 46-keV region. (auth)

**17554** MAGNETIC CONFIGURATION OF SUNSPOT GROUPS WHICH PRODUCE SOLAR PROTON FLARES. Sakurai, Kunitomo (Goddard Space Flight Center, Greenbelt, Md.). Planet. Space Sci.; 18: 33-40(Jan 1970).

The configuration of sunspot magnetic fields is deduced by using the observational data on the development of type IV radio bursts and H$\alpha$-brightening areas over the umbrae of sunspot groups. Since both polarity areas are existent together within the same umbrae, the magnetically neutral regions are usually produced

along the areas separating the one polarity area from the other. In the eastern portion of the preceding sunspots, the gradient of sunspot magnetic fields is much steeper compared to all other portions and thus solar proton flares are triggered within or very near this portion. Hα-brightening areas develop mainly above the preceding sunspots and their eastern portion of sunspot groups. This tendency seems to be closely related to the configuration of sunspot magnetic fields and the mechanism of solar proton flares. (auth) (UK)

**17555** SOLAR ACTIVITY, 27-DAY VARIATION, AND LONG-TERM MODULATION OF COSMIC-RAY INTENSITY. Balasubrahmanyan, V. K. (Goddard Space Flight Center, Greenbelt, Md.); Venkatesan, D. Solar Phys.; 11: 151-4(Jan 1970).

The effect of the double maxima in the 11-year cycle of solar activity pointed out by Gnevyshev (1963, 1967) is detected both in the long term modulation and the 27-day variation in cosmic-ray intensity. A linear relation between the amplitude of the 27-day variation and the cosmic-ray intensity is obtained. The constraints that this observation puts on theories of modulation of cosmic-ray intensity are discussed. (W.D.M.)

**17556** DISCUSSION OF PAPER, A COMPARISON OF ENERGETIC STORM PROTONS TO HALO PROTONS. Lanzerotti, L. J. (Bell Telephone Labs., Murray Hill, N. J.). Solar Phys.; 11: 145-7(Jan 1970).

This note makes use of newly published low-energy solar particle data from Explorer 34 for two of the May 1967 events discussed by Kahler (1969). These data suggest for these two events, that although the energetic storm particles were originally solar particles, other processes were subsequently operative on these particles in their travel to the earth. These solar-originated particles were accelerated or confined in interplanetary disturbances, becoming energetic storm particles; so that they cannot be uniquely identified as halo-type particles. A reply by Kahler is included. (W.D.M.)

**17557** SOLAR X-RAY BURSTS AT ENERGIES LESS THAN 10 keV OBSERVED WITH OSO-4. Culhane, J. L.; Phillips, K. J. H. (Univ. College, London). Solar Phys.; 11: 117-44(Jan 1970).

Using data from a proportional counter spectrometer, sensitive in the wavelength range 1 to 20 Å, on OSO-4, x-ray bursts in the energy band 3.0 to 4.5 keV have been studied. 150 events have been identified between October 27, 1967 and May 8, 1968, mostly of an impulsive nature. Some gradual rise and fall bursts occur, but there is a selection bias against such long-enduring events. A study of the profiles of these events reveals no basis for identifying different types of impulsive event. Single frequency radio bursts and Hα flares of class >1F are almost always accompanied by x-ray enhancements. For the sample of x-ray events, only 25% are correlated with radio bursts and 46% with flares. Only 11% of the sample events are associated with type III radio bursts. Microwave burst peaks occur an average of two minutes earlier than the x-ray burst peak, but the first observation of x-ray activity is usually before the start of the corresponding microwave burst. Impulsive bursts, although differing widely in fall time, are due to the heating of a volume of plasma from a temperature of 10.0 to $30.0 \times 10^6$ K. Differences in fall time probably indicate different electron densities in the source. Observation of an iron line at 1.9 Å suggests that a nonthermal mechanism may be operating during some of these events since the temperatures are too low to permit thermal excitation of the $1s^2-1s2p$ transition in $Fe^{+24}$. It is also possible that, in spite of the low temperature, most of the iron ions have been stripped to the $Fe^{+24}$ stage. Collisional excitation and dielectronic recombination processes would then be able to provide the observed flux in the resonance line of $Fe^{+24}$. A gradual rise and fall event and event "precursors" have also been studied. (auth)

**17558** PULSATING RADIO EMISSIONS FROM THE SOLAR CORONA. Abrami, A. (Astronomical Observatory, Trieste, Italy). Solar Phys.; 11: 104-16(Jan 1970).

Three solar outbursts which show pulsating radio emissions at metric waves (239 MHz) are examined. The behavior of the single frequency, high-time resolution records and the spectral diagrams seem to indicate that such phenomena are peculiar phases of type IV radiation, perhaps connected with absorptions in the solar corona. The spectral analysis of the low-frequency modulation of the emissions show a very definite spectral line with a period ranging from 1.7 to 3.1s. (auth)

**17559** TRAJECTORIES FOLLOWED BY U-LIKE SOLAR RADIO BURSTS. Fokker, A. D. (Utrecht Univ.). Solar Phys.; 11: 92-103(Jan 1970).

Radiospectrographic observations of some U-like bursts have been employed in combination with a model coronal condensation due to Waldmeier to derive trajectories along which the disturbing agency, which excites the radio emission, may have travelled. Such trajectories as connect regions of opposite magnetic polarity within one center of activity should have a parachute-like shape in order to account for the observations. Travelling velocities are of the order of 35,000 to 55,000 km/sec. Moreover, the distribution of U-like bursts in heliographic longitude is investigated and an attempt is made to explain the fact that the second branches of U-like bursts are less developed than the first branches. (auth)

**17560** CORONAL POLARIZATION AND INTENSITY AT THE NOVEMBER 12, 1966 SOLAR ECLIPSE. Arnquist, Warren N. (McDonnell Douglas Corp., Huntington Beach, Calif.); Menzel, Donald H. Solar Phys.; 11: 82-91(Jan 1970).

The 1966 Douglas Solar Eclipse Expedition obtained photographic records of the intensity and polarization of the solar corona on November 12, from a site at Chiguata, Peru. The present paper amplifies a preliminary account in a special publication (Proceedings: Eclipse Symposium, Sao Jose dos Campos, February 5–9, 1968, in press). Here a more complete description is given of the equipment, its calibration, methods of reduction, and the results obtained. The observed intensities and polarizations are compared with those predicted by van de Hulst and structure indicated by the polarization data is pointed out. These observations reveal the existence of complicated structures with intensities and polarization both higher and lower than required by the van de Hulst model. In general high intensities correlate with high polarizations and low intensities with low polarization. However, some instances occur where seemingly normal intensities are associated with lower polarizations and low intensities with high polarizations. These discrepancies are accounted for in terms of electron concentrations along the line of sight, which do not occur in the simplified model corona. Further, it is suggested that the existence of structure, such as streamers, rays, and so on, in the outer corona indicates that the current models tend to underestimate the importance of the K corons in this region. (auth)

**17561** EXCITATION EQUILIBRIUM OF CORONAL IONS. Zirker, J. B. (Univ. of Hawaii, Honolulu). Solar Phys.; 11: 68-81(Jan 1970).

The relative populations of levels of highly ionized Fe, Ni, and Ca ions were calculated for physical conditions appropriate to the solar corona. The results are presented in the form of tables. Line intensity ratios in the euv and visible that are sensitive to electron density are discussed and compared with observations. (auth)

**17562** MODEL FOR QUIESCENT PROMINENCES WITH HELICAL STRUCTURE. Anzer, Ulrich; Tandberg-Hanssen, E. (High Altitude Observatory, Boulder, Colo.). Solar Phys.; 11: 61-7(Jan 1970).

A model is presented for quiescent prominences with helical structure. The model is described by two magnetic fields, one produced by photospheric or subphotospheric currents, the other due to currents along the cylindrical model prominence. (auth)

**17563** LIFETIME OF DARK AND BRIGHT MOTTLES OF THE SOLAR CHROMOSPHERE. Macris, C. J.; Alissandrakis, C. E. (Astronomical Inst., Athens). Solar Phys.; 11: 59-60(Jan 1970).

The determination of the lifetime of bright and dark mottles, which are short-lived formations of the chromosphere, is considered necessary for their study. A series of photographs of the chromosphere were taken with the 40-cm refractor of the National Observatory of Athens. These photographs were used to make a study of the mean lifetime of the bright and dark mottles. (W.D.M.)

**17564** SOLAR XUV LIMB-BRIGHTENING OBSERVATIONS. I. THE LITHIUM-LIKE IONS. Withbroe, George L. (Harvard Coll. Observatory, Cambridge, Mass.). Solar Phys.; 11: 42-58 (Jan 1970).

OSO-IV observations of the equatorial limb brightening of xuv resonance lines of $N_{V}$, $O_{VI}$, $Ne_{VIII}$, $Mg_{X}$, and $Si_{XII}$ are interpreted with a modified version of a coronal model developed by Dupree and Goldberg (1967). Good agreement is obtained between the observed limb brightening and that predicted by the model. The sensitivity of the predicted limb-brightening curves to changes in parameters describing the model is discussed. Coronal abundances for N, O, Ne, Mg, and Si are obtained. (auth)

**17565** DETERMINATION OF ELECTRON DENSITY IN PLASMA BY THE NUMBER OF THE EXTREME RESOLVED LINE. Kurochka, L. N.; Maslennikova, L. B. (Kiev State Univ.). Solar Phys.; 11: 33-41(Jan 1970).

It is shown that the dependence of the number of the extreme resolved line on the electron density obtained for the Balmer series (Kurochka, 1967) considering the broadening action of the electrons, remains true for the Lyman and Paschen series as well. For these

series a formula which gives the dependence of the number of the extreme resolved line on the velocity of hydrogen atoms when the lines are broadened by the Doppler effect, has been derived. The dependence of the number of the extreme resolved line on the electron density at different values of atom velocities for the joint action of the Stark and Doppler effects is also given. The electron density in certain chromospheric flares, prominences, and in the chromosphere has also been determined. (auth)

17566 PENUMBRAL MAGNETIC FIELD STRENGTHS. Mallia, E. A. (Univ. Observatory, Oxford). Solar Phys.; 11: 31-2(Jan 1970).

In a recent paper Altrock (1969) showed that thermal effects alone are unable to account for the low contrast between penumbra and photosphere in the line of O (7772 Å). A penumbral magnetic field of about 1500 g also has to be invoked. Similar values of the field strength at the center of penumbrae have been found by Beckers and Schröter (1969). In this note more data for penumbral magnetic fields are given. (W.D.M.)

17567 ON SMALL-SCALE MOTIONS IN THE PHOTOSPHERE AND CHROMOSPHERE OF THE SUN. Abdusamatov, H. I.; Krat, V. A. Solar Phys.; 11: 29-30(Jan 1970).

A series of spectrograms of the Hα, 6280 Å, and $D_1$,$D_2$ regions was obtained using a four-camera isothermic spectrograph in the 4th order with a dispersion of 3.7 mm/Å (at Hα). (W.D.M.)

17568 SHORT-PERIOD OSCILLATIONS AND DOPPLER VELOCITY GRADIENTS. Harvey, J. (Kitt Peak National Observatory, Tucson, Ariz.). Solar Phys.; 11: 26-8(Jan 1970).

In order to test the hypothesis of Howard and Livingston on short-period oscillations of the photosphere, simultaneous observations of the Doppler velocity and the magnitude of local Doppler velocity gradients were made with the Kitt Peak magnetograph. (W.D.M.)

17569 DEPTH-DEPENDENT LINE BLANKETING BY NEUTRAL AND IONIZED METALS IN A HOMOGENEOUS MODEL SOLAR PHOTOSPHERE. Margrave, Thomas E. Jr. (Univ. of Montana, Missoula). Solar Phys.; 11: 22-5(Jan 1970).

Line blanketing due to both the neutral and ionized metals is treated by the modified picket-fence method and applied to the case of a homogeneous model solar photosphere in strict radiative equilibrium. Improvement in fitting the observed photospheric radiation field is noted over a model in which the line absorption coefficient is constant with depth. (auth)

17570 ISOTOPE RATIO OF EUROPIUM IN THE SOLAR ATMOSPHERE. Hauge, Oeivind (Univ. of Oslo). Solar Phys.; 11: 17-21(Jan 1970).

Europium has two stable isotopes, $^{151}$Eu and $^{153}$Eu. The high isotope shift and the different hyperfine splitting of the energy levels of the two isotopes make it possible to study the isotope ratio by an analysis of the spectral line profiles. From five spectral lines the solar isotope ratio is found to be equal to the terrestrial ratio within an error limit of about 10%. (auth)

17571 SOME OSCILLATOR STRENGTHS IN THE SPECTRA OF C I, O I, Si I, Ca II, AND Sr II. Van Rensbergen, Walter (Astronomical Inst., Utrecht. Free Univ., Brussels). Solar Phys.; 11: 11-16(Jan 1970).

A number of wave functions for bound electrons have been calculated in scaled Thomas-Fermi ion potentials in order to evaluate some oscillator strengths and mean square radii. The results differ only slightly from those obtained by the well-known method of Bates and Damgaard. After that, the values of the oscillator strengths for the transition 4s → 4p in $Si_I$ have been evaluated in intermediate coupling, showing large differences with the LS-coupling results. These new values are supported by the fact that they show somewhat better agreement with observations, described earlier in this issue of Solar Physics by De Jager and Neven. (auth)

17572 DAMPING CONSTANTS FOR INFRARED FRAUNHOFER LINES. de Jager, C. (Astronomical Inst., Utrecht); Neven, L. Solar Phys.; 11: 3-10(Jan 1970).

Empirical values of solar damping constants and their variation with optical depth were derived according to a method developed earlier by the authors. The damping constants refer to six infrared multiplets (24 lines). The average optical depths range from $\tau_0$ = 0.5 to 2.2. Corresponding theoretical damping constants were computed, mainly on the basis of Van der Waals damping, and with the help of detailed computations of the mean square radii of the atomic levels by Van Rensbergen. The empirical values are systematically larger than the theoretical ones, with factors ranging between 1.8 and 4.9. Some speculations about the source of this discrepancy are given. (auth)

17573 STUDY ON THE STATISTICAL EQUILIBRIUM OF THE ION Ar XIV LEVEL-POPULATION IN CORONAL CONDITIONS. Lexa, J. (Astronomical Inst., Skalnate Pleso, Czech.). Bull. Astron. Inst. Czech.; 20: 373-80(1969).

Transition probability coefficients for transitions between energy levels of the ion Ar XIV were computed. Beside permitted spontaneous and collisional transitions also spontaneous, radiative, and collisional transitions between levels of the fundamental term $2p^1P^0$ were taken into consideration. For the afore-mentioned energy levels of the ion Ar XIV a system of equations of statistical equilibrium was solved. The relative population of the first six excited levels at different values of parameters $N_e$, $T_e$, and $\rho$ is shown. (auth)

17574 SOLAR X RAYS: DEVELOPING BACKGROUND FOR COMPREHENSIVE THEORY. Kreplin, Robert W. (Naval Research Lab., Washington, D. C.). Astronaut. Aeronaut.; 7: No. 12, 58-65(Dec 1969).

This article describes one salient area of the broad spectrum of solar observational research — solar x radiation. The article attempts to develop an insight into the phenomena of solar activity based on observations of solar x-ray emission. (W.D.M.)

17575 CHROMOSPHERE–CORONA TRANSITION REGION. Pneuman, G. W. (National Center for Atmospheric Research, Boulder, Colo.). Sky Telesc.; 39: 148-51(Mar 1970).

An attempt is made to understand the dynamics and energetics of the corona/chromosphere transition region in context with the corresponding properties of both the chromosphere and the corona. The very existence of these regions is believed to be dependent upon the dissipation of upward propagating sound waves generated in the convection zone beneath the photosphere. (W.D.M.)

17576 DIELECTRONIC RECOMBINATION. Shore, Bruce W. (Harvard Coll. Observatory, Cambridge, Mass.). Astrophys. J.; 158: 1205-18(Dec 1969).

This paper derives the rate coefficient for dielectronic recombination (inverse auto-ionization) by using results from the quantum theory of resonance-collision processes, with attention to coupling schemes, degeneracy, and overlapping resonances. Numerical results, derived by using screened hydrogenic wave functions, are presented for several configurations. (auth)

17577 THE $n^3P_2$–$1^1S_0$ MAGNETIC-QUADRUPOLE TRANSITIONS OF THE HELIUM SEQUENCE. Drake, G. W. F. (Smithsonian Astrophysical Observatory, Cambridge, Mass.). Astrophys. J.; 158: 1199-1203(Dec 1969).

Accurate variational calculations are presented for the $2^3P_2$–$1^1S_0$ magnetic-quadrupole decay rates of the helium-like ions He I to Ne IX. It is shown that Z-expansion results for $^1P$–$^1S$ electric-dipole transitions are easily modified to obtain the Z-expansion of the corresponding $^3P$–$^1S$ magnetic-quadrupole transition. The Z-expansion parameters are presented for the $n^3P_2$–$1^1S_0$ transitions, with n = 2(1) 20. (auth)

17578 ASTROPHYSICAL DAMPING CONSTANTS FOR NEUTRAL IRON. Cowley, Charles R.; Elste, Guenther H.; Allen, Robert H. (Univ. of Michigan, Ann Arbor). Astrophys. J.; 158: 1177-81(Dec 1969).

Empirical damping constants are derived for twenty-six lines of neutral iron by using the solar spectrum. Eight of these lines have also been measured by Kusch, and the agreement between the two sets of measurements is satisfactory. It is suggested that these damping constants may be used to obtain abundances and to strengthen spectroscopic determinations of surface gravity. (auth)

## Galaxies

*Refer also to abstracts 17615 and 17847.*

17579 PRIMORDIAL SYNTHESIS OF SUPERHEAVY NUCLEI IN THE GALAXY. Kuchowicz, B. (Univ. of Warsaw). Nature (London); 225: 440-1(31 Jan 1970).

There is stated to be astrophysical evidence in favor of the hypothesis that an appreciable amount of heavy elements was produced in a giant explosion in the nucleus of the galaxy about $7 \times 10^9$ years ago, and cosmochemical arguments could support the concept of the presence of massive bulks of prestellar matter in the nuclei. Synthesis of heavy elements in exploding massive bulks of prestellar matter may proceed preferentially, through some kind of neutron capture process; this synthesis will occur predominantly in the external layers, where the density of matter falls below a subnuclear value of $10^{13}$ g/cm$^3$ and the matter exists in the so-called "ne A" phase (neutrons, electrons, nuclei). Synthesis of nuclei up to U in such high density conditions has been considered (Amiet and Zeh, Phys. Lett. 25B: 305 (1967), Z. Phys. 217: 485

(1968)), and there has been much theoretical work on the region near the doubly closed shell nucleus $^{298}114$, in connection with the possible island of stability near Z = 114. The nuclide $^{294}110$ was considered the best candidate for survival. Experimental searches for this and closely related elements are in progress, and there are certain indications in favor of extinct superheavy elements in meteorites, from isotopic anomalies in the Xe and Kr composition. In addition to the probably single event of synthesis in explosion in the galactic core the continuous mechanism of production in supernova explosions should be taken into account, an estimate of the production of $\sim 10^{28}$ nuclei of element 110 per sec in the Galaxy in this way was obtained. Because the prestellar matter bulks are relativistic objects, detailed results should be obtained within the theory of relativity which will determine the time scale of the process in the galactic core. (UK)

**17580** NONLINEAR DENSITY WAVES IN THE GALAXY GASDYNAMICAL APPROXIMATION. Niimi, Hideyuki (Kyoto Univ.). J. Phys. Soc. Jap.; 28: 232-7(Jan 1970).

Nonlinear density waves in a rotating stellar system are investigated within the framework of the gasdynamic approximation endowing the system with an isotropic pressure. The waves are assumed to be one-dimensional and steady in a uniformly rotating local coordinate system and to propagate at a constant velocity perpendicular to the axis of rotation. The results show that the waves are wave trains for the cases of supersonic flows, and that the waves are wave trains, or solitary waves for the cases of subsonic flows. (auth)

**17581** DIFFUSE COMPONENT OF THE COSMIC FAR-UV RADIATION AND INTERSTELLAR DUST GRAINS. Hayakawa, S.; Yamashita, K.; Yoshioka, S. (Nagoya Univ., Japan). Astrophys. Space Sci.; 5: 493-502(Dec 1969).

The diffuse far-uv radiation (1350 to 1480 Å) observed in the sky region of $l^{II} \approx 180°$, $0° \leq b^{II} \lesssim 40°$ is analyzed in connection with the distributions of stars and dust grains as well as with optical properties of grains. Its intensity (starlight + scattered light) is about $6 \times 10^{-7}$ erg cm$^{-2}$ sec$^{-1}$ sr$^{-1}$ Å$^{-1}$ in the direction of $b^{II} \approx 0°$ and $l^{II} \approx 180°$. The latitude dependence of the intensity is in approximate agreement with the plane parallel slab model of the Galaxy with a reasonable set of parameters. The interstellar scattering gives an albedo close to unity and forward phase function of about 0.6, which are not inconsistent with the model of interstellar grains of Wickramasinghe. The upper limit of the extragalactic uv is $2 \times 10^{-8}$ erg cm$^{-2}$ sec$^{-1}$ sr$^{-1}$ Å$^{-1}$ in the same region of wavelength. (auth)

**17582** BARRED SPIRAL GALAXIES. Burbidge, Margaret. Comments Astrophys. Space Phys.; 2: 25-34(Jan-Feb 1970).

The following topics are discussed: the linear rotation curve of NGC 7479 and Prendergasts' model, noncircular motions in several barred spirals and Freeman's model, and the barred spirals in a general scheme of galactic evolution. (M.H.R.)

**17583** HEAT EQUATION AND THE SPIRAL STRUCTURE OF DISK GALAXIES. Nahon, Fernand (Laboratoire de Dynamique Stellaire, Paris). Compt. Rend., Ser. A; 269: 823-5(29 Oct 1969). (In French).

The gravitational theory of Lin and Shu (Astrophys. J., 140: 646(1964)) is taken up again, and it is shown that the variations of radial velocity are determined by a Fourier equation in which the space and time variables are permuted and the scattering coefficient is imaginary. (tr-auth)

**17584** ORIGIN OF THE OPTICAL POLARISATION IN THE NUCLEUS OF NGC 1068. Nandy, K. (Royal Observatory, Edinburgh). Nature (London); 225: 621-2(14 Feb 1970).

In measurements of the polarization of the nuclear region of NGC 1068 it was found that the degree of polarization increased with decreasing diaphragm size, suggesting that the polarization is produced in and close to the nucleus and that the radiation contributed by other parts of the galaxy is unpolarized. In order to find what processes are responsible for the optical radiation from the nucleus it was important to determine the intrinsic polarization of the nucleus, and for this a dilution factor, D, was required which was the ratio of the integrated surface brightness of all the radiation from the galaxy within the diaphragm to that of the nucleus; the method of computing this factor is described, and the value obtained was $D \geq 16.9$. Before allowance was made for the dilution factor it seemed reasonable to suggest that a $\sim$ 0 to 5% degree of polarization should be produced by optical synchrotron radiation but to explain a 40% polarization (taking into account the dilution factor) is much more difficult; not only is a strong magnetic field ($\gtrsim 10^{-3}$G) required, but it must also be well ordered over dimensions ~50pc (the minimum diameter of the nucleus). A possibility is that the dust surrounding the nucleus required to explain the infrared radiation, could be strongly aligned and could produce the strong polarization, but for perfectly aligned grains of iron or graphite a maximum polarization of only 25 to 30% can be obtained. A further possibility is that if the nucleus is surrounded by a suggested dense shell of grains then much of the light from the nuclear region may be scattered by the grains. Given a model of the dust shell in which the grain density decreases outwards so that most of the scattering is at phase angles of 90° ± 35°, and given very small grains which scatter according to the Rayleigh–Gans theory, so that the degree of polarization of the first order scattered light lies between 50 and 100%, it is conceivable that the 40% polarization might be explained. (UK)

**17585** PHOTOELECTRIC SPECTROPHOTOMETRY OF Hγ IN EARLY-TYPE STARS. Code, Arthur D. (Univ. of Wisconsin, Madison. Kitt Peak National Observatory, Tucson, Ariz.); Hoag, A. A. Publ. Astron. Soc. Pac.; 81: 848-53(Dec 1969).

In the course of a spectrophotometric program (Code's) involving observations of extragalactic sources, the writers obtained spectrum scans of several early type stars including three O stars in NGC 1893. The purpose of this communication is to report on the measurements of the equivalent widths of Hγ in these stars and to describe the technique employed. (auth)

**17586** COLOR INDICES OF THE GLOBULAR CLUSTERS OF THE FORNAX DWARF GALAXY. Hodge, Paul W. (Univ. of Washington, Seattle. Cerro Tololo Inter-American Observatory, La Serena, Chile). Publ. Astron. Soc. Pac.; 81: 875-8 (Dec 1969).

New measurements of the UBV color indices of five globular clusters in Fornax indicate that they have normal values and that the previous report of abnormal color indices is in error. A total absolute magnitude of $M_V \simeq -7.0$ is derived for a sixth cluster, which appears to be a normal globular cluster. (auth)

**17587** TWO-COLOR PHOTOGRAPHIC PHOTOMETRY OF THREE POSSIBLE OPEN STAR CLUSTERS. Nelson, Robert M. (Wesleyan Univ., Middletown, Conn.). Publ. Astron. Soc. Pac.; 81: 900-4(Dec 1969).

A method by which open clusters have been found is by searching for condensations of young stars using objective prism plates. Roslund (1960) using this technique noted that there might be seven heretofore-undetected open clusters in the Milky Way. In this study, three of these suspected clusters were investigated photographically in two colors (B and V) and color–magnitude diagrams are presented. (W.D.M.)

**17588** 1s 2s STATES OF NEGATIVE HYDROGEN. Ingemann-Hilberg, Claus; Rudkjoebing, Mogens (Univ. of Aarhus, Denmark). Astrophys. Space Sci.; 6: 101-6(Jan 1970).

Term values for the 1s 2s states of $H^-$ are calculated with the use of simple eigenfunction approximations constructed on the basis of available Hartree-type functions for the $1s^2$ and $2s^2$ states of the ion. The results seem to support a tentative identification of the interstellar diffuse absorption bands at λ4890 and λ6180 as due to negative hydrogen. (auth)

**17589** MOTION OF AN INTERSTELLAR GRAIN. Ireland, J. G. (Royal Observatory, Edinburg). Astrophys. Space Sci.; 6: 107-17(Jan 1970).

The motion of an interstellar grain is discussed, with account taken of the various resistive forces acting on it. Grains may survive and escape from an H II region surrounding a central star in periods of $\sim 10^6$ to $10^8$ years, depending on the temperature of the exciting star. It is suggested that, under special circumstances, gas may diffuse out of the region faster than the grains. (auth)

**17590** SHAPE OF THE INTERSTELLAR ABSORPTION BAND. Wickramasinghe, N. C.; Nandy, K. (Royal Observatory, Edinburg). Astrophys. Space Sci.; 6: 154-6(Jan 1970).

Profiles of the 4430 band are calculated for resonant absorbers distributed within graphite particles, silicate particles, and solid-$H_2$ grains. The sizes of grains adopted are those which give agreement with the interstellar extinction. Only in the latter two cases can satisfactory agreement be obtained with recent observational data. (auth)

**17591** GALACTIC LONGITUDE DEPENDENCE OF THE INTENSITY RATIO OF THE DIFFUSE INTERSTELLAR ABSORPTION BANDS AT λλ6180 AND 4430. Rudkjoebing, Mogens (Univ. of Aarhus, Denmark). Astrophys. Space Sci.; 6: 157-60(Jan 1970).

Equivalent widths, as published by Seddon, for the diffuse interstellar absorption band at λ6180 are compared with photoelectric λ4430 indices for ten stars in the northern Milky Way. The intensity ratio is found to depend on galactic longitude in a way similar to that found by Johnson for the ratio $A_V/E_{B-V}$ of total to selective interstellar absorption. The dependence found, combined with de-

ductions from a tentative identification of the bands as due to negative hydrogen, points to a direction for the galactic magnetic field that is in better agreement with the direction derived from rotation measures of extragalactic sources than with that based on the dust-hypothesis interpretation of interstellar optical polarization. (auth)

**17592** ABOUT KERR'S GALACTIC EXPANSION AND WEBER'S GRAVITATION SIGNALS. Jordan, P. (Univ. Hamburg). Z. Phys.; 233: 84-8(1970). (In German).

The expansion of the Galaxy seeming to be detected by Kerr can probably not be explained as resulting from a rapid diminution of the central mass of the Galaxy (this hypothesis being put forward by Field, Rees, Sciama). But it follows as a consequence from the scalar–tensor theory of gravitation (as developed by Jordan, Thiry, Brans–Dicke) if the value $\dot{t}/t = -\epsilon$, as taken from the difference between ephemeris time and inertial time, has the correct order of magnitude. The events in the nucleus of the Galaxy, triggering the Weber signals, must probably be collisions between neutron stars and normal stars. (auth)

**17593** FORMATION AND EQUILIBRIUM OF INTERSTELLAR CLOUDS. Goldsmith, Donald William. Berkeley, Calif.; Univ. of California (1969). 116p.

Thesis.

This investigation into the physical conditions of the interstellar medium is based on calculations of the heating by low-energy cosmic rays and leads to an equilibrium mode in which two thermally stable gas phases coexist in pressure equilibrium, one at $T \approx 10^{4\cdot6}$K and one at $T < 300$°K. The hot gas, which is about 10% ionized, occupies most of interstellar space. Gravitation in the z-direction compresses about 75% of the material present into the cool, dense phase to form clouds. A theoretical study of instabilities within the hot, rarefied intercloud medium has been made both analytically, using the linearized equations of constraint that include changes in the ionization, and numerically, with the aid of a computer hydrodynamics program to follow perturbations into the nonlinear regime. The results of these calculations show that typical e-folding times are $\sim 10^7$ years at the onset of instability ($n = 0.21$ cm$^{-3}$, $T = 7800$°K, $n_e/n = 0.075$) and decrease rapidly as the disturbance grows, so that a typical time of cloud formation is $\sim 5 \times 10^7$ years if the instability grows along the magnetic field lines. The program was also used in one-dimensional spherical form to study the effects of a piston advancing into the initially homogeneous, rarefied intercloud medium. (Diss. Abstr. Int., B)

**17594** THE EXTINCTION LAW IN THE MAGELLANIC CLOUDS. Brueck, M. T. (Royal Observatory, Edinburgh); Lawrence, L. C.; Nandy, K. N.; Thackeray, A. D.; Wood, R. Nature (London); 225: 531-2(7 Feb 1970).

The Magellanic clouds contain only small amounts of obscuring matter compared with the Galaxy, and the maximum reddening observed is of the order $E_{B-V} = 0.5$ magnitudes. UBV photometry suggests that extinction follows the $1/\lambda$ law. In a detailed study of the extinction law, spectra of reddened stars in the large and small Magellanic clouds were recorded with the 72-inch telescope at Pretoria. Each plate included spectra of an MC star and a galactic star of the same spectral type. In order to avoid spurious effects caused by atmospheric extinction the galactic stars and the time of their observation were chosen so that their zenith distance should be the same as that of their partner MC stars. In addition, each plate included a set of spectra of another galactic star taken at different zenith distances to monitor atmospheric extinction, and photometric calibration was imposed on each plate by a multiple slit calibration spectrograph. Stellar and calibration spectra were recorded with a digitized microdensitometer. Data for spectra of four Magellanic cloud stars and three galactic comparison stars are given in tabular form. The Magellanic cloud stars were all supergiants, which could not be readily matched by similarly luminous class applied to the magnitude differences. The extinction law in the Magellanic clouds is compared graphically with the galactic extinction laws for the direction of Cygnus and Perseus. The data obtained also included two pairs of Magellanic cloud stars of the same spectral type and luminosity class but of different reddening; by differencing these pairs the difficulties of luminosity class discrepancy and foreground reddening were avoided. The observations suggested that the extinction law in the Magellanic clouds resembles the Perseus rather than the Cygnus law and that the change in slope in the neighborhood of $1/\lambda = 2.3$ $\mu$m$^{-1}$ is similar to that found in the galactic extinction laws, the importance of which, if confirmed, is discussed. The results suggest that the composition, size, and optical properties of dust grains in the Magellanic clouds resemble those in the anticenter region of the Galaxy. (UK)

**17595** COMPACT COMPANIONS CONNECTED TO 3C 371. Arp, Halton (Mount Wilson Observatory, Pasadena, Calif. Palomar Observatory, Pasadena, Calif.). Astrophys. Lett.; 5: 75-9(Feb 1970).

It is shown that the radio galaxy 3C 371 lies in a loose chain of compact galaxies. Luminous extensions connect it to the nearest companions in the chain. The redshift of the cluster is smaller by about a factor two than would be predicted by the standard redshift-apparent magnitude relation for clusters of galaxies. (auth)

**17596** SPECTRUM AND REDSHIFT OF THE OPTICALLY VARIABLE, COMPACT RADIO GALAXY 3C 371. Arp, Halton (Mount Wilson Observatory, Pasadena, Calif. Palomar Observatory, Pasadena, Calif.); Visvanathan, N. Astrophys. Lett.; 5: 73-4(Feb 1970).

Only very low contrast emission lines of [O II], [O III], and [Ne III] can be identified in the spectrum of 3C 371. Their mean redshift is $z = 0.0501 \pm 0.001$. A few other lines, which appear to be real, cannot be identified. Some other compact galaxies with similar properties are compared with 3C 371. (auth)

**17597** STRUCTURE OF THE COMA CLUSTER OF GALAXIES. Peebles, P. J. E. (Princeton Univ., N. J.). Astron. J.; 75: 13-20(Feb 1970).

In some cosmologies, a cluster of galaxies is imagined to be a gravitationally bound system which, in analogy with the formation of the Galaxy, originated as a collapsing protocluster. It is shown that a numerical model based on this picture is consistent with the observed features of the Coma Cluster of galaxies. The cluster mass derived from this model agrees with previous values; however, an analysis of the observational uncertainty within the framework of the model shows that the derived mass could be consistent with the estimated total mass provided by the galaxies in the cluster. (auth)

**17598** ON THE HOMOGENEITY OF THE SPECTRAL-ENERGY DISTRIBUTION AMONG GIANT E AND SO GALAXIES AND OTHER RESULTS. Lasker, Barry M. (Carnegie Institution of Washington, D. C. California Inst. of Tech., Pasadena). Astron. J.; 75: 21-33(Feb 1970).

A system of intermediate-bandwidth photometry, whose eight passbands located between 3400 and 8000 Å generally avoid strong line features for redshifts up to ~5000 km/sec, was used to observe about 100 galaxies, primarily E's and S0's. The results were corrected for the effects of reddening in our Galaxy and for the influence of redshift on the filter passbands. For each color index formed, the scatter in colors among the giant E's and S0's is small (0.04 to 0.11 mag, depending on the specific color index), and at least part of this scatter is real, not observational. If this scatter in the spectral-energy distributions among the local galaxies ($v \lesssim 5000$ km/sec) is representative of that for more distant ones also, then the small associated uncertainty in the K correction can be estimated to be $\delta K \sim 0.06\,z$, where z is the redshift; the error in determining the deceleration parameter due to this error in K is about $\delta q_0 \simeq 0.06$. Differences among the observed galaxies are discussed in terms of the scatter in their colors. Among the brightest galaxies ($-21 \lesssim M$), the color–magnitude correlation is weak, but significant correlations exist over the larger range in absolute magnitude obtained by including dwarf galaxies ($M \sim -15$). The colors appear to be weakly correlated with $\sigma$, the internal velocity dispersion. (auth)

**17599** SPECTROPHOTOMETRY OF THE NUCLEUS OF THE SEYFERT GALAXY NGC 4051. Andrillat, Yvette (Montpellier Univ., France); Souffrin, Suzy. Compt. Rend., Ser. B; 270: 238-40(19 Jan 1970). (In French).

The spectrum of the Seyfert Galaxy NGC 4051 consists of a continuous spectrum on which are superimposed absorption and emission lines. The nucleus is made up of two types of stars (A and G) and a plasma. (auth)

**17600** INTERSTELLAR ABSORPTION IN SELECTED AREA 47. Schreur, Julian J. (Univ. of Arizona, Tucson). Astron. J.; 75: 38-41(Feb 1970).

A study of the obscuration in the direction of Selected Area 47 ($l^{II} = 159°$, $b^{II} = -21°$) was made. A total visual absorption of 2.5 m was found within a distance of 500 pc. (auth)

**17601** STABILITY PROBLEM OF OSCILLATIONS ALONG THE AXIS OF SYMMETRY IN A GALAXY. I. THE FIRST ORDER PERTURBATIONS IN NON-RESONANCE CASES. Andrle, P. (Astronomical Inst., Prague). Bull. Astron. Inst. Czech.; 20: 317-22(1969).

The stability problem of oscillations along the axis of symmetry of a galaxy is studied by Jacobi's and "Lagrange's" equations. If there are no commensurabilities the amplitudes of $\bar{\omega}$ and z oscillations possess no secular terms. Secular terms among perturbations of $t_\omega$ and $t_z$ occur if the powers of $\bar{\omega}$ and z are even. The

influence of the perturbing term $\beta\omega^2 z^2$ is studied as a special example. The upper and lower limits of both coordinates are found in this case and one may state: If only the first-order perturbations are considered, then the oscillations are stable. (auth)

**17602** THE VARIABLE COMPACT GALAXY Zw 0039.5 + 4003. Zwicky, F. (Carnegie Institution of Washington, D. C. California Inst. of Tech., Pasadena); Oke, J. B.; Neugebauer, G.; Sargent, W. L. W.; Fairall, A. P. Publ. Astron. Soc. Pac.; 82: 93-8(Feb 1970).

The optically variable compact galaxy Zw 0039.5 + 4003 has broad emission lines similar to those seen in Seyfert and N-type galaxies. The continuous spectrum shows no evidence of any stellar contribution and is probably largely nonthermal. The object has a redshift z = 0.1026 and an absolute visual magnitude of −21.6. (auth)

**17603** LOW-DISPERSION SPECTRA OF GALAXIES. I. THE COMA AND VIRGO CLUSTERS. Philip, A. G. Davis (State Univ. of New York, Albany); Sanduleak, N. Publ. Astron. Soc. Pac.; 82: 53-68(Feb 1970).

Low-dispersion objective-prism spectra (≈10,000 Å/mm) were obtained of galaxies in the Coma and Virgo clusters. Composite color indices were derived from the spectra which, when combined with magnitudes obtained from the Catalogue of Galaxies and Clusters of Galaxies (Zwicky and Herzog 1963), allowed color–magnitude diagrams for the clusters to be drawn. The differences between the diagrams for different clusters indicate that the method will prove useful in the study of the color distribution within clusters of galaxies. The main use of the spectral indices will be in the identification of the bluest and reddest galaxies, which might warrant further study. (auth)

**17604** COLLISIONS BETWEEN INTERSTELLAR H I CLOUDS. Stone, Michael Eric. Princeton, N. J.; Princeton Univ. (1969). 103p.

Thesis.

Numerical, hydrodynamical models were developed for head-on collisions between two identical interstellar clouds. Nonadiabatic cooling by atomic line radiation and heating by cosmic rays are both included explicitly. The one-dimensional model consists of the collision between two slabs of gas infinite in extent transverse to the collision direction. The two-dimensional model involves two initially spherical clouds of 350 solar masses each. (TSS) (Diss. Abstr.)

**17605** LOW-DISPERSION SPECTRA OF GALAXIES. II. HERCULES AND ABELL NOS. 2197 AND 2199. Philip, A. G. Davis (State Univ. of New York, Albany). Publ. Astron. Soc. Pac.; 82: 69-79(Feb 1970).

Low-dispersion spectra (≈10,000 Å/mm) were obtained of the brighter members of the Hercules cluster and Abell Nos. 2197 and 2199. The survey identifies the reddest and bluest galaxies in each cluster. Color–magnitude diagrams are drawn for each cluster. (auth)

## Cosmology

*Refer also to abstract 18288.*

**17606** HIGH-PRECISION TESTS OF GENERAL RELATIVITY. Thorne, Kip S.; Will, Clifford M. Comments Astrophys. Space Phys.; 2: 35-41(Jan-Feb 1970).

The possibilities for testing which relativistic theory of gravity is the correct one are reviewed and the efforts that are necessary for a full exploitation of these tests are pointed out. The types of relativistic theories which are to be tested and the non-Newtonian effects which they predict for the solar system are reviewed. (M.H.R.)

**17607** THE UNIVERSE AS A HOT LABORATORY FOR THE NUCLEAR AND PARTICLE PHYSICIST. Zeldovich, Ya. B. Comments Astrophys. Space Phys.; 2: 12-17(Jan-Feb 1970).

Information about particle physics which could be extracted if one accepts the hot Universe picture, keeping in mind the subsequent cooling of the Universe, is considered. Nuclear and particle physics experiments which could confirm or disprove the hot-Universe theory are discussed. Several arguments, quite independent one from the other, are mentioned. (W.D.M.)

**17608** ORBITING CLOCK EXPERIMENT TO DETERMINE THE GRAVITATIONAL RED SHIFT. Kleppner, Daniel (Massachusetts Inst. of Tech., Cambridge); Vessot, Robert F. C.; Ramsey, Norman F. Astrophys. Space Sci.; 6: 13-32(Jan 1970).

Plans are presented for an experiment to measure the gravitational redshift of the Earth by comparing a ground-based and satellite-borne hydrogen maser clock. The limiting accuracy is estimated to yield a determination of the redshift to 1 part in $10^4$, corresponding to a clock stability of 3 parts in $10^{15}$. (auth)

**17609** NOTE ON THE POSSIBILITY OF EXISTENCE OF A DENSE INTERGALACTIC PLASMA. Bergeron, J. (Institut d'Astrophysique, Paris). Astron. Astrophys.; 4: 335-6(Feb 1970).

Earlier determination of the minimum temperature of a dense, hot, intergalactic gas (Bergeron, 1969) has been deduced from the lack of Lyman $\alpha$ absorption in the emission spectra of the quasi-stellar objects, taking as Lyman-$\alpha$ optical depth $\tau \leqq 0.0625$. If the observations of the emission spectra of the QSO set an upper limit on the Lyman-$\alpha$ optical depth of only $\tau \leqq 0.4$ the hypothesis of a hot dense intergalactic gas ($q_0 = 1$) is not in contradiction with both observations of the isotropic x-ray background around 0.27 keV and the emission spectra of the QSO. (auth)

**17610** NEUTRINOS AND ARROW OF TIME IN COSMOLOGY. Chaudhuri, P. Ray (Indian Statistical Inst., Calcutta). J. Phys., A (London); 3: L5-6(Mar 1970).

The arrow of time in the case of neutrinos is investigated, taking into account photon–neutrino weak-coupling theory. It is shown that in both steady-state and Einstein–de Sitter cosmological models, the advanced effect can be avoided. (auth) (UK)

**17611** RELATIVISTIC ANALOGS OF SCALAR-TENSOR COSMOLOGIES. McIntosh, C. B. G. (Univ. of New England, Armidale, Australia). J. Math. Phys. (N. Y.); 11: 250-2(Jan 1970).

Relativistic analogs of Brans–Dicke and Hoyle–Narlikar scalar–tensor cosmologies are given in terms of two- or three-fluid models. Each fluid has an equation of state of the form pressure = const × density. The models discussed have the matter and scalar fluids interacting and are expressed by different forms of $E_i$, where this is the total new rate of transfer of energy per unit volume to the $i$th fluid from all other fluids. (auth)

**17612** EXTRAGALACTIC DISTANCE SCALE. Van de Bergh, S. (Univ. of Toronto). Nature (London); 225: 503-5(7 Feb 1970).

It is stated that nine distinct methods of distance determination beyond the local Group are now available, and these nine methods are used to determine the value of the Hubble constant. A mean value $H = 95^{+15}_{-15}$ km s$^{-1}$ Mpc$^{-1}$ is obtained from available data. Among matters discussed are diameters of H II regions, luminosity classification of galaxies, brightest globular clusters in galaxies, mass-to-light ratios, the third brightest cluster galaxy, supernovae and the extra-galactic distance scale, surface brightness and diameter of galaxies, brightest stars in galaxies, regional variations of the Hubble constant. (UK)

**17613** HOYLE–NARLIKAR QUANTISATION OF WHEELER–FEYNMAN ELECTRODYNAMICS. Katz, A.; Orman, E.; Schwartz, M. (Weizmann Inst. of Science, Rehovoth, Israel). Nature (London); 225: 534-5(7 Feb 1970).

Hoyle and Narlikar (Ann. Phys., 54: 207(1969)) proposed a quantized version of the Wheeler–Feynman (Rev. Mod. Phys., 17: 157(1945) and 21: 425(1949)) theory of classical electrodynamics. It is stated in the present communication that the HN treatment of spontaneous emission deviates from the WF theory, and that this is true even in the classical limit where, however, the numerical effects of two different deviations cancel. The WF theory is based on the postulates that charged particles interact via time symmetric electromagnetic fields, and that there is no self-interaction; it then takes into account the response of all charged particles in the Universe to the field of each accelerated charge. The response field accounts for radiation reaction and also reestablished the full retarded field around each accelerated particle and defines a universal direction of time in which all the retarded potentials point. The prescription for computing the response of the Universe to the field of an accelerated particle a is to let each charged particle b in the Universe be excited by the full retarded and attenuated field of a, and then b react on a with one half its advanced field unattenuated. The reaction field in the HN treatment is the full advanced field, attenuated. The use of the full advances and attenuated field rather than half the advanced field tends to double the radiation reaction, but the attenuation tends to cut it down exactly by half. Whether the effects of doubling the response field and of attenuating it also cancel outside the classical limit should be made clear. (UK)

**17614** PARTICLES IN EINSTEIN UNIVERSE. Sharma, N. K. (Univ. of Rajasthan, Jaipur, India). Curr. Sci. (India); 39: 82-3(20 Feb 1970).

In recent years Riemannian manifolds $V_4$ with the respective groups of motion $G_n$, $0 \leq n \leq 10$, have been extensively used in particle physics. One aspect of this study is to investigate the eigenvalue problem of the Laplace–Beltrami operator as a generalized Klein–Gordon equation with Riemannian background.

In this note an investigation of this problem with the use of static spherically symmetric Einstein manifold is reported. (W.D.M.)

**17615** SPAN OF THE GALACTIC CLUSTER OF VIRGO AND THE VALUE OF THE HUBBLE CONSTANT. Heidmann, Jean (Observatoire de Paris-Meudon, Meudon, France). Compt. Rend., Ser. B, 268: 1782-4(June 30, 1969). (In French).

The relation existing between the linear diameters and the intrinsic luminosities of the spiral galaxies is calibrated from standard galaxies whose distances are known. The application of this relation to the cluster of Virgo leads to a module of distance higher than a unit of the generally accepted value for this cluster and to a low value of the Hubble constant: 50 km/s Mpc. (tr-auth)

**17616** METAGALACTIC INVERSE COMPTON EFFECT AND COSMIC X-RAY BACKGROUND. Fukui, Mitsuru; Hayakawa, Satio (Nagoya Univ., Japan). Progr. Theor. Phys. (Kyoto); 42: 1129-38(Nov 1969).

It has been pointed out that the diffuse component of cosmic x rays could be accounted for in terms of the inverse Compton collisions of relativistic electrons with universal black-body photons. This hypothesis is examined, taking into account evolutionary effects that result in decreases of the energy density of the universal black-body radiation and of the production rate of relativistic electrons with cosmic age. The results obtained are: (1) the spectrum of x rays bends at about 0.3 keV according to the energy loss of electrons due to the inverse Compton effect and (2) the magnetic field strength in radio galaxies should be as low as $10^{-7}$ to $10^{-8}$ gauss if the electrons had an intensity high enough to explain the x-ray intensity and the same electrons were responsible for radio emission. The bending energy given in (1) is much lower than the observed one; thus the inverse Compton effect cannot explain the bending of the x-ray spectrum. The second conclusion (2) is much more severe than that obtained by Bergamini et al.; the magnetic field strength required seems to be unreasonably low. The results are thus unfavorable to the inverse Compton effect hypothesis. (auth)

### *Planetary Phenomena*

**17617** THE IONOSPHERES OF VENUS AND MARS. II. MARINER V AND THE VENUS IONOSPHERE. Goody, Richard. Comments Astrophys. Space Phys.; 2: 7-11(Jan-Feb 1970).

In part I a discussion was given of the expected structure of the Martian atmosphere prior to Mariner IV flyby, and of the revision of ideas forced by the results from the flyby experiment. When Mariner V flew by Venus in Oct. 1967, electron density profiles were obtained for both daytime and nighttime. The significance of the data and some assumptions derived therefrom are discussed briefly. (W.D.M.)

**17618** MODULATION LANES IN THE DYNAMIC SPECTRA OF JOVIAN L BURSTS. Riihimaa, J. J. (Univ. of Colorado, Boulder). Astron. Astrophys.; 4: 180-8(Feb 1970).

The fine structure of the dynamic spectra of Jovian L bursts displays repeated, tilted lanes. A spaced-spectrograph experiment in which two identical radio spectrographs at 21 to 23 MHz were operated over a 160-km baseline indicated that the lanes originate at Jupiter. The interplanetary scintillation only affects the group appearance of the lanes. The sign and magnitude of the drift of these lanes is a strong function of System III central meridian longitude of Jupiter. The lanes are an intensity effect. A possible explanation is that they are produced by wave-like disturbances in the Jovian ionosphere or magnetosphere causing oscillations in the direction of the emission sheet at Jupiter. (auth)

**17619** TOPSIDE IONOSPHERE OF VENUS AND ITS INTERACTION WITH THE SOLAR WIND. Bauer, S. J.; Hartle, R. E.; Herman, J. R. (Goddard Space Flight Center. Greenbelt, Md.). Nature (London); 225: 533-4(7 Feb 1970).

It is stated that the abrupt termination of the daytime ionosphere of Venus at about 500 km, as observed with the Mariner V two-frequency occulation experiment, provides an interesting example of the direct interaction of the solar wind with a planetary ionosphere, and the authors used the observed properties of the solar wind to determine order of magnitude estimates of the characteristic parameters in this interaction. Among other things a pressure balance at the stagnation point formed with the streaming pressure of the solar wind leads to a magnetic field build-up of approximately 50γ. The important constraints that the solar-wind interaction places on a self-consistent model of ionospheric temperatures and densities are discussed. The presence or absence of a magnetic field within the ionosphere has important consequences for the structure of the Venus ionosphere, and an induced magnetic field due to the interaction of the solar wind with the conducting ionosphere or the pressure of a small intrinsic planetary magnetic field can lead to a nonhorizontal field within the Venus ionosphere; the upper limit for such a field is estimated at 40γ. A relatively simple photochemical model for the lower regions of the ionosphere is discussed, assuming $CO_2$ to be the dominant heavy neutral species at 100 km and H and He to be the important light neutral constituents. As a result of hydrostatic equilibrium, H and He are the dominant species at higher altitudes, and the ionization peak at about 130 km will be controlled by the neutral $CO_2$, while the charged-particle pressure in the topside will be strongly influenced by H and He. The usual balance equations of hydrostatic pressure, including gravitational and electrical forces, were solved for the light ions $H^+$ and $He^+$, and combining these with the equations arising from the thermal balance in a multicomponent plasma a self-consistent solution for temperatures and densities was obtained. The computed ionospheric model with $He^+$ as the dominant ion is shown. The peak of electron density and the scale height of topside electron density for this model are in good agreement with the Mariner occultation data. A similar model satisfying the observed conditions is that where $H^+$ (or $D^+$) is the dominant ion, but the high value required for the $H^+$ density (and/or $D^+$ density) in the topside ionosphere seems unlikely. The charged-particle pressure distribution in the topside ionosphere is also shown graphically, and the very slow pressure decrease with altitude suggests that the altitude at which the ionosphere terminates is a strong function of solar wind pressure. Because the streaming pressure of the solar wind on the night side of Venus is negligible, the ionosphere there would extend to considerable altitudes, as reported by Mariner V. (UK)

**17620** THERMAL HISTORY OF THE MOON. Gilvarry, J. J. (General Dynamics, San Diego, Calif.). Nature (London); 225: 623-5(14 Feb 1970).

The heat conduction equation for the Moon is examined, and corrections are offered to previous solutions; possible thermal histories consistent with the present thermal regime are discussed. The thermal history of a planetary body after full accretion is controlled by the internal heat from radioactive decay, as specified by the equation of heat conduction. Isotope abundances are also discussed, with particular reference to Th/U and K/U. Solutions of the equation of heat conduction are shown graphically as a function of depth for a Moon initially at 0°C with uniformly distributed radioactivities; also shown is a curve for an initially cold Moon heated by chondritic radioactivity. Melting in the lunar material at any epoch is considered. (UK)

**17621** SPECTRAL OBSERVATIONS OF JUPITER IN THE FREQUENCY INTERVAL 18.5 TO 24.0 GHz: 1968. Jones, D. E. (Brigham Young Univ., Provo, Utah); Meredith, B. L.; Arthur, E. Publ. Astron. Soc. Pac.; 82: 122-5(Feb 1970).

Results of observations of Jupiter in the frequency range 18.5 to 24.0 GHz near the opposition of 1968 are reported. For 13 days in the time interval Jan. 16 to April 10, 1968, Jupiter was observed at seven discrete local oscillator frequencies: 18.5, 20.0, 21.5, 22.235, 23.00, 23.87, and 24.0 GHz. (W.D.M.)

**17622** OBSERVATIONS OF SATURN AT λ3.75 cm. Seling, Theodore V. (Univ. of Michigan, Ann Arbor). Astron. J.; 75: 67-8(Feb 1970).

Observations of Saturn were made at λ3.75 cm and a disk temperature of (168 ± 11)°K was obtained. This value is consistent with measurements made at other wavelengths. The spectrum of Saturn shows an upturn at longer wavelengths, suggesting the possibility of nonthermal radiation from Saturn. (auth)

## Atomic and Molecular Physics

**17623** ATOMIC PHYSICS. Born, Max. London; Blackie (1969). 509p. 70s.

Revision of the Original Translation.

The following topics are discussed: kinetic theory of gases; elementary particles; the nuclear atom; wave-corpuscles; atomic structure and spectral lines; spin of the electron and Pauli's principle; quantum statistics; molecular structure; quantum theory of solids; nuclear physics (size of nuclear and α decay); angular momentum and magnetic moment; the deuteron and nuclear forces; nuclear structure and nuclear saturation; nuclear shell model; the nuclear collective model; β decay and K capture; nuclear electromagnetic interactions; the drop model, nuclear reactions and fission. The text was completely revised and some substantial changes were made. Advanced mathematical proofs of physical formulae are given in appendixes. (UK)

## Atomic, Electron, Ion, and Molecular Beams and Their Reactions

*Refer also to abstracts 16453, 18025, and 18032.*

17624 (NYO-3829-45) SOLUTION OF THE EQUATIONS OF MOTION IN CLASSICAL AND QUANTUM THEORIES. Bialynicki-Birula, I. (Pittsburgh Univ., Pa. Dept. of Physics). Jan 1970. 37p. Dep. CFSTI.

The relationship between the time dependence of quantum operators in the Heisenberg picture and the time dependence of the corresponding dynamical variables in the underlying classical theory is discussed. This problem is studied in the non-relativistic particle mechanics and in the field theory. It is shown how the operator solutions of the quantum equations of motion are related to the corresponding solutions of the classical equations of motion. An explicit formula is given, which expresses quantum operators in the Heisenberg picture in terms of their classical counterparts. This formula is particularly useful in the study of the classical limit of the quantum theory. The dependence on $\hbar$ of the matrix elements of the coordinate and field operators is explicitly given, which enables one to study quantum corrections to the classical theory in all orders. Coherent states of the quantum system play an essential role in the formalism. (auth)

17625 (ORO-3799-3) SPIN INTERACTIONS BETWEEN SLOW ELECTRONS AND AMINO ACID FILMS. Progress Report II, March 1, 1969–February 28, 1970. Yeargers, Edward (Georgia Inst. of Tech., Atlanta. Engineering Experiment Station). 1 Mar 1970. Contract AT(40-1)-3799. 20p. Dep. CFSTI.

The multiplicities and populations of electronic excited states produced in aromatic amino acids under bombardment by electrons with energies between approximately 0 and 1000 eV were investigated. A three-fold approach was used during the past year: (1) ab initio quantum mechanical calculations were made for a system involving two orbital electrons and an incident electron, (2) semi-empirical self-consistent-field calculations of the excited-state $\pi$-electron charge densities of tyrosine were made and, (3) equipment including an electron gun and a uv–visible emission spectrometer was constructed and leak tested, and spectral data for tryptophan at 300°K and 77°K were recorded. Electrons with energies below 1000 eV generate emission spectra at 300°K that are more characteristic of those produced by x rays and fast electrons than those produced by uv irradiation. In particular, an emission band centered at about 5500 Å and found only for irradiation by ionizing radiation exhibits progressively greater intensity as incident-electron energy is decreased to 150 eV, the lowest incident-electron energy used to date. Spectra taken at 77°K also are more characteristic of those generated by ionizing radiation than those generated by uv. The number of emissive singlet states produced compared to emissive triplet states at 77°K decreases steadily as incident-electron energy decreases. These data are consistent with the hypothesis of the original proposal that low-energy electrons can be expected to produce long-lived triplet states more efficiently than higher-energy electrons in solid biochemicals. (auth)

17626 NONUNITARY BOGOLYUBOV TRANSFORMATIONS AND EXTENSION OF WICK'S THEOREM. Balian, R.; Brezin, E. (Centre d'Etude Nucleaires, Saclay, France). Nuovo Cim.; 64B: 37-55(11 Nov 1969).

Linear transformations are considered, which preserve the (anti-) commutation rules, but not the Hermiticity relation, for (fermion) boson creation and annihilation operators; these transformations lead to Fock space representations on biorthogonal bases of the operator algebra. As an application, an extension of Wick's theorem to matrix elements of an arbitrary operator between two different quasi-particle vacuums is derived. This theorem is useful for calculations which go beyond the variational Hartree-Fock-Bogolyubov methods (H.F.B. with projection, generator co-ordinate method, etc.). A canonical decomposition for Bogolyubov transformations is established, which proves useful, for instance, in the calculation of the overlap of two different quasi-particle vacuums. (auth)

17627 INVESTIGATION OF THE ANGULAR DEPENDENCE OF THE SECONDARY ELECTRON EMISSION COEFFICIENT AND THE SPUTTERING YIELD BY ION BOMBARDMENT OF CYLINDRICAL TARGETS IN A PLASMA. Oechsner, H.; Gesang, W. R. (Univ., Wuerzburg, Ger.). Z. Naturforsch.; 24a: 1908-14(Dec 1969). (In German).

The influence of the angle of incidence of low energy ions on the emission of secondary particles from solid surfaces can be investigated by using cylindrical targets in a low pressure plasma. It is shown that the distribution of the angle of incidence of the impinging ions becomes independent of plasma conditions and bombarding parameters, when the diameter of the Langmuir sheath around the target is sufficiently large compared with that of the cylindrical target. Experimental results on the influence of the angle of ion incidence on the secondary electron emission coefficient and the sputtering yield are reported for polycrystalline Mo bombarded with $Ar^+$-ions from 300 to 900 eV. (auth)

17628 RANGE OF ELECTRONS AND CONTRIBUTION OF BACKSCATTERED ELECTRONS IN SECONDARY PRODUCTION IN ALUMINIUM. Thomas, S.; Pattinson, E. B. (Univ. of Keele, Eng.). J. Phys., D (London); 3: 349-58(Mar 1970).

The range of electrons as a function of primary energy below 2 keV, the escape depth of slow secondaries, and the efficiency of backscattered electrons in the production of slow secondaries were determined in thin aluminum layers deposited on platinum, gold, and silver substrates, using an automatic yield-measuring device, which enables the measurements to be made from contamination-free surfaces. (auth) (UK)

17629 Ni L SELF-ABSORPTION SPECTRUM. Chopra, D. (East Texas State Univ., Commerce). Phys. Rev., A; 1: 230-5 (Feb 1970).

The shape and position of the Ni L$\alpha$ x-ray emission line ($\lambda$ = 14.53 Å) were studied as a function of bombarding electron energy ranging from 2 to 30 keV. The bombarding electrons struck the anode at normal incidence, and x rays were viewed by the spectrometer at a 90° takeoff angle. The Ni L$\alpha$ lines recorded under these conditions exhibit an increasing attenuation of intensity on the high-energy side and a shifting of the peak position toward lower energy with increasing bombarding electron energy. These changes are interpreted as due to differential self-absorption of the emission line in the anode. The emission measurements were used to obtain the "L self-absorption spectrum" of Ni, which agrees favorably with the absorption spectrum reported in the literature. (auth)

## Atomic and Molecular Properties

*Refer also to abstracts 17439, 17486, 17528, 17538, 17588, and 17895.*

17630 (N-69-39419) CONSTANT OF STEP-BY-STEP IONIZATION OF ATOMS. Smirnov, B. M. Translated from Dokl. Akad. Nauk SSSR; 187: 787-90(1969). 8p. (NASA-CR-106263). CFSTI.

The constant of step-by-step ionization in a large discharge tube by way of its dependence on temperature and density of electrons and properties of different atomic gases is studied. The ratio of such constants is established for two such gases. The earlier calculations by Bates are proved to be incorrect. (auth) (STAR)

17631 WAVE FUNCTIONS AND TRANSITION RATES OF $H_2^+$ FOR LARGE INTERNUCLEAR SEPARATION. Smith, William Freeman Jr. Lexington, Ky.; Univ. of Kentucky (1968). 64p. Thesis.

Calculations of transition rates and wave functions for $H_2^+$ for the region of large internuclear separation were performed, in order to extend the work of Ross past 250 Bohr radii. These same transition rates were calculated (to terms in 1/R) using the asymptotic wave functions of Coulson to test the usefulness of this expansion for this region. The technique used to obtain the eigenvalues and the coefficient in the expansions of the wave functions is an alteration of the standard continued fraction method. The formulas obtained for the asymptotic transition rates are found to be quite accurate for R > 250 Bohr radii for most of the transitions considered. The results indicate that the use of the Born–Oppenheimer approximation is warranted, at least in the region of interest to plasma physicists. (Disser. Abstr.)

17632 SPIN–OTHER-ORBIT AND SPIN–ORBIT INTERACTIONS FOR SOME RARE EARTH IONS. Saxena, K. M. S.; Malli, Gulzari (Simon Fraser Univ., Burnaby, British Columbia). Can. J. Phys.; 47: 2487-91(15 Nov 1969).

The spin–other-orbit and spin–orbit interactions are evaluated for $Pr^{3+}(4f^2)$, $Nd^{3+}(4f^3)$, $Er^{3+}(4f^{11})$, and $Tm^{3+}(4f^{12})$ using the general matrices of these interactions for $f^2$ and $f^3$ electron configurations reported earlier. (auth)

17633 SPIN–OTHER-ORBIT AND SPIN–ORBIT SPLITTING FACTORS IN $f^5$ ELECTRON CONFIGURATIONS. Saxena, K. M. S.; Malli, Gulzari (Simon Fraser Univ., Burnaby, British Columbia). Can. J. Phys.; 47: 2805-10(15 Dec 1969).

The expressions of the spin–other-orbit splitting factors ($\lambda'$) for all the states arising from $f^5$ electron configurations are com-

puted and tabulated for general usage. These are used to evaluate the Hartree–Fock values of $\lambda'$ and $\lambda$ for Pm($4f^5$), $Sm^{3+}(4f^5)$, Tb($4f^8$), and $Dy^{3+}(4f^9)$. (auth)

**17634** OSCILLATOR STRENGTHS FOR HELIUM. Cameron, Stella (York Univ., Toronto); McEachran, R. P.; Cohen, M. Can. J. Phys.; 48: 211-15(15 Jan 1970).

Oscillator strengths for 95 singlet and triplet s–p and p–d transitions in neutral helium were calculated using analytical wave functions of the "frozen-core" type. Both length and velocity formulations of the oscillator strengths were employed. The results are generally in good agreement with the most accurate values available. (auth)

**17635** STUDIES OF $He^+$ ION MOTIONS IN He IN CROSSED ELECTRIC AND MAGNETIC FIELDS. Pasechnik, L. L.; Yagola, V. V. Zh. Tekh. Fiz.; 39: 2198-2202(Dec 1969). (In Russian).

Helium ion drift in the electric fields perpendicular to the magnetic field was determined by measuring the rate of ion movement from the axis of a cylinder to its walls. Correlations of calculated and experimental data showed that, in the case of weak electric fields, the ion motion in the direction perpendicular to the magnetic field, was $b_\perp \sim [1/1 + (\omega^2/\nu^2)]$ (when $\omega$ and $\nu$ are the cyclotron frequency and frequency of ion collisions with neutral atoms, respectively). In the region of strong electric fields the conditions, during which $b_\perp \sim [1/\sqrt{1 + (\omega^2/\nu^2)}]$, could also be found. (tr-auth)

**17636** THE "s" LINE IN THE L SPECTRUM OF Gd. Nigam, A. N.; Kapoor, Q. S. (Univ. of Rajasthan, Jaipur, India). Chem. Phys. Lett.; 4: 639-40(1 Feb 1970).

A 20-cm curved mica crystal spectrograph of the transmission type was used to study the alpha region of the L spectrum of gadolinium. A new diagram line corresponding to the quadrupole transition $L_{III}M_{III}(s)$ at $\lambda$ = 2171.3 X.U. is reported for the first time. (auth)

**17637** ON THE REALIZATION OF THE SYMMETRY GROUP OF THE NONRELATIVISTIC HYDROGEN ATOM. Decoster, Alain (Commissariat a l'Energie Atomique, Limeil-Brevannes, France). Compt. Rend., Ser. A; 270: 290-3(26 Jan 1970). (In French).

It is shown that the Fock transformation consists in connecting two different problems and changing the physical content of the operator. The hermiticity of the operators is checked in detail, and the transformation rules are consequently altered. (auth) (France)

**17638** ATOMIC SPECTRA. (SECOND EDITION). Kuhn, H. G. London; Longmans, Green and Company Ltd. (1969). 481p. 105 s.

The following topics are discussed: classical mechanics of the atom; the old quantum theory; the methods of quantum mechanics; the radiation of atoms; hydrogen and the hydrogen-like ions; configuration interaction; multiplet spectra; hyperfine structure; isotope shifts; radiofrequency spectra; width and shape of spectral lines. (UK)

**17639** ON THE ELECTRIC DIPOLE MOMENT OF HD. Karl, Gabriel (Oxford Univ.). Can. J. Phys.; 46: 1973-4 (1 Sep 1968).

A formula is proposed to represent the J dependence of radial matrix elements of the electric dipole moment of HD. (auth) (Canada)

**17640** NEW RESULTS IN THE STUDY OF GADOLINIUM ARC SPECTRUM: NEW ELECTRON CONFIGURATIONS AND HIGH ODD LEVELS. Blaise, Jean (CNRS, Orsay, France); Wyart, Jean-Francois; Van Kleef, Theodorus Antonius Marie. Compt. Rend., Ser. B; 270: 261-3(26 Jan 1970). (In French).

From the Zeeman effect and from parametric calculations, six new electron configurations were located, as well as 97 new high old levels. (auth) (France)

**17641** STARK EFFECT IN He II AND H. Bashkin, S. (Univ. of Arizona, Tucson); Carriveau, G. W. Phys. Rev., A; 1: 269-73(Feb 1970).

The beam–foil light source was used for a study of the Stark effect on $He^+$ ($\lambda$4686 Å) and H$\beta$. For the former, the p and s components were detected for transverse and longitudinal fields. The transverse-field data suggest that levels of high j are underpopulated relative to their equilibrium numbers. The longitudinal-field data are anomalous. For H$\beta$, splitting was observed, but the arrangement precluded the detection of polarization. The data also imply underpopulation of levels of high j. (auth)

**17642** FREQUENCY-DEPENDENT POLARIZABILITY OF $H_2$ CALCULATED BY MANY-BODY THEORY. Kelly, Hugh P. (Univ. of Virginia, Charlottesville). Phys. Rev., A; 1: 274-9 (Feb 1970).

Many-body perturbation theory is used to calculate the parallel and perpendicular dynamic polarizabilities of molecular hydrogen. High-order terms in the perturbation expansion are included and the poles of $\alpha(\omega)$ are calculated. Results for the dynamic dipole polarizabilities and for the molecular anisotropy are in good agreement with experiment. (auth)

**17643** DYNAMIC COUPLING PHENOMENA IN MOLECULAR EXCITED STATES. I. GENERAL FORMULATION AND VIBRONIC COUPLING $H_2$. Berry, R. Stephen (Univ. of Chicago); Nielsen, Svend Erik. Phys. Rev., A; 1: 383-94(Feb 1970).

A general formalism is described for treating diabatic coupling processes in highly excited molecular states. The method treats electronic and nuclear motion quantum mechanically, and uses the adiabatic Born–Oppenheimer states as basis functions. The present paper concentrates on diagnoses of vibronic coupling matrix elements, with Rydberg and continuum states of $H_2$ as the test cases. The principal contributions come from the excited electron's interactions with the oscillating finite monopole of the ion–molecule core. The electronic factors in the transition amplitudes are definitely dependent on internuclear distance, particularly in the cases of p and d states. The transition amplitudes accumulate their magnitudes over the full classically allowed range of internuclear distance, especially in the cases of s and p states. Specific application is made to vibronic coupling perturbations in p$\sigma$ and p$\pi$ Rydberg states of $H_2$. (auth)

**17644** DYNAMIC COUPLING PHENOMENA IN MOLECULAR EXCITED STATES. II. AUTOIONIZATION AND PREDISSOCIATION IN $H_2$, HD, AND $D_2$. Berry, R. Stephen (Univ. of Chicago); Nielsen, Svend Erik. Phys. Rev., A; 1: 395-411(Feb 1970).

Vibrationally induced autoionization and one class of predissociation of electronically excited $H_2$ and its isotope are treated by a perturbed-stationary-state theory. Autoionization and predissociation rates are given for a number of states of $H_2$, HD, and $D_2$. In addition to direct bound–continuum coupling, consideration is given to effects of higher-order coupling; these effects cause order-of-magnitude changes in isolated cases. The autoionization rates vary with principal quantum number n as $n^{-3}$, directly with vibrational energy $v\hbar\nu$, and decrease sharply with vibrational quantum change $\Delta v$. As the principal quantum number increases, transitions of successively smaller $\Delta v$ becomes possible; the net effect of this is to override the $n^{-3}$ dependence in total autoionization rates. Competition between predissociation and autoionization is examined; the two processes show very different dependence on n and v, with the consequence that decay in most regions of (n,v) space is dominated by one or the other process; but the two mechanisms are competitive for some (n,v) states. The isotope effect also is rather different for the two decay processes, enough so that, in effect, the isotope effect amounts to a qualitative change from one mechanism of decay to the other, with mass change. (auth)

**17645** SPIN-PROJECTED HARTREE–FOCK CALCULATIONS ON THE He-LIKE IONS USING GENERAL SPIN ORBITALS. Lunell, Sten (Univ. of Florida, Gainesville). Phys. Rev., A; 1: 360-9(Feb 1970).

Spin-projected Hartree–Fock (PHF) wave functions are obtained for the isoelectronic series $H^-$, He, $Li^+$, and $Be^{++}$, using different orbitals for different spins and general spin-orbitals (GSO), in both cases of pure s character. The GSO energy for He is −2.87887 a.u., accounting for 99.1% of the radial correlation energy. A natural orbital analysis of the GSO function shows that it corresponds to a configuration interaction function with three $s^2$ configurations. The one-electron energies obtained from the PHF equations are given an interpretation as ionization energies. In the GSO case, the one-electron energies are not unique, but an upper limit is obtained. (auth)

**17646** PRELIMINARY ANALYSIS OF THE SPECTRUM OF TRIPLY IONIZED GADOLINIUM (Gd IV). Kielkopf, J. F.; Crosswhite, H. M. (Johns Hopkins Univ., Baltimore). J. Opt. Soc. Amer.; 60: 347-51(Mar 1970).

The emission spectrum of doubly and triply ionized gadolinium from 1200 to 6000 Å is reported. A pulsed hollow-cathode light source was used with a 5-m Czerny–Turner vacuum spectrograph to obtain wavelengths and photoelectric intensities for 12,000 lines of doubly ionized gadolinium and 8000 lines of triply ionized gadolinium. For the fourth spectrum, a preliminary analysis indicates that the $4f^86s - 4f^86p$ transitions occur at 45,000 $cm^{-1}$ and the $4f^7 - 4f^75d$ transitions at 75,000 $cm^{-1}$. The stronger lines from these regions determine 32 low-lying levels of these configurations. (auth)

**17647** MEAN LIVES OF SOME EXCITED LEVELS IN He I. Martinson, I.; Bickel, William S.; Bromander, J.; Berry, H. G.; Lundin, L.; Buchta, R.; Bergstroem, I. (Research Inst. for Physics, Stockholm). J. Opt. Soc. Amer.; 60: 352-3(Mar 1970).

A beam of $^4He^+$ ions from an isotope separator was sent through a thin exciter foil to study the beam–foil spectrum of He I. The mean lives of seven levels were measured. (auth)

**17648** $4f^{14}6sns$, $4f^{14}6snd$, AND $4f^{14}6snp$ SEQUENCES IN Yb I. Nir, S. (Hebrew Univ., Jerusalem). J. Opt. Soc. Amer.; 60: 354-7(Mar 1970).

Energy levels belonging to higher members of the $4f^{14}6sns$, $4f^{14}6snd$, and $4f^{14}6snp$ sequences in Yb I are identified. Calculations based on the Ritz–Rydberg formula for the various series confirm these identifications and also result in consistent values for the ionization potential. Coupling schemes for the $4f^{14}6snd$ and $4f^{14}6snp$ sequences are discussed. The results obtained are compared with those of similar sequences of the type $4f^N6sns$, $4f^N6snd$, and $4f^N6snp$ in Ba I and in Eu I. (auth)

**17649** CHANGE OF K-SHELL BINDING ENERGIES WITH IONIC CHARGE. Baroody, E. M. (Battelle Memorial Inst., Columbus, Ohio). J. Opt. Soc. Amer.; 60: 418-19(Mar 1970).

A procedure for calculation of the change of K-shell binding energies with ionic charge from tables of ionization potentials is described briefly. The procedure is based on the assumption that a hole in the K shell is nearly the same as one extra unit of charge on the nucleus. Numerical results are shown for copper for ionization stages through n = 19. Comparison with results of others indicates that the method can give improved estimates for elements from Z = 11 to 30 and help in determination of K and L binding energies for heavier elements. (A.G.W.)

**17650** SPECTRUM OF TRIPLY IONIZED GADOLINIUM. Kielkopf, John Francis Jr. Baltimore; John Hopkins Univ. (1969). 155p.

Thesis.

The emission spectrum of doubly and triply ionized gadolinium was measured from 1200 to 6000 angstroms. For this purpose a new source using a hollow gadolinium cathode was developed, which is pulsed repetitively with peak currents that may be varied from 60 to 2000 amperes. The spectrum of this source operated at different currents was photographed with a five-meter Czerny–Turner spectrograph equipped with an interferometrically ruled grating blazed for 59,000Å in the first order, and measured with a semi-automatic comparator. Photoelectric measurements of line intensities under similar conditions allow a uniform intensity scale to be established. The final line list comprises 12,000 lines of doubly ionized gadolinium and 8000 lines of triply ionized gadolinium with the separation of ionization stages based primarily upon photoelectric intensity measurements. For the fourth spectrum the bunching of lines within the observed spectral range indicates that $4f^6 6s - 4f^6 6p$ transitions occur at 45,000 $cm^{-1}$, $4f^7 - 4f^6 5d$ transitions at 77,000 $cm^{-1}$, and $4f^6 5d - 4f^6 6p$ transitions at 75,000 $cm^{-1}$. Attempts to analyze the structure of these four basic configurations with the method of common differences were only partly successful, primarily because of the large number of accidental coincidences. The problem of analyzing complex spectra by the method of common differences alone is discussed, and the results of a preliminary analysis of the s–p and f–d transitions are presented. (Diss. Abstr.)

**17651** THE SPECTRUM OF Nd IV. Irwin, David Joseph Garnet. Baltimore; Johns Hopkins Univ. (1969). 103p.

Thesis.

The neodymium metal spark spectrum was photographed between 1180 and 6700 Å, using unidirectional pulsed discharges of 30, 200, 400, and 600 amperes peak currents. Inspection of the relative intensities allows a separation of the spectrum of the triply ionized ion from spectra of the lower ionization stages. Altogether some 10,000 lines were measured and recorded on punched cards and magnetic tape. Approximately 1000 of the strongest lines in the 400-A discharge are listed here. Several fragmentary groups of energy levels were found. Some correlation with theoretical levels was made, but it has not yet been possible to make connections between all the levels. (Diss. Abstr.)

**17652** THE DETERMINATION OF SOME X-RAY ATTENUATION COEFFICIENTS IN THE RANGE 26.3 TO 2.3 keV. Dalton, J. L. (Dept. of Energy, Mines, and Resources, Ottawa); Goldak, J. Can. Spectrosc.; 14: 171-3(Nov 1969).

The range of measured coefficients for Pr, Gd, Er, V, Ti, Fe, Ni, and Cu is expanded and the reliability of Heinrich's tables illustrated. The measurements were made on a 100-kV Norelco constant potential single-crystal x-ray spectrometer. (Canada)

## *Positronium, Muonium, and Mesic Atoms and Molecules*

*Refer also to abstract 16918.*

## *Collision Phenomena*

**17653** (AD-693127) IONIZATION AND EXCITATION OF NITROGEN BY PROTONS AND HYDROGEN ATOMS IN THE ENERGY RANGE 1 TO 25 keV. Technical Report, July 1, 1968–May 1, 1969. McNeal, Robert J.; Clark, David C. (Aerospace Corp., El Segundo, Calif.). 1 Jul 1969. Contract F04701-69-C-0066. 28p. (TR-66(9260-1)-1; SAMSO-TR-69-273). CFSTI.

Recent measurements of the energy spectra of protons and hydrogen atoms in breakup auroras have found significant fluxes at energies near 1 keV. Cross sections for ionization and light emission for collisions of protons and hydrogen atoms with atmospheric gases are useful in analysis of these auroral events. Atomic-beam measurements are reported of ionization and charge-capture cross sections for proton bombardment of $N_2$, of ionization and stripping cross sections for hydrogen-atom bombardment of $N_2$, and of the relative cross sections for emission of $N_2^+$ 391.4-nm radiation in collisions of protons and hydrogen atoms with $N_2$ in the energy range 1 to 25 keV. (auth) (USGRDR)

**17654** (N-69-35508) COMPUTER PLOTTING DESCRIPTION OF ION–MOLECULE COLLISIONS WITH LONG-LIVED CAPTURE COMPLEXES. Dugan, John V. Jr.; Rice, James H. (National Aeronautics and Space Administration, Cleveland, Ohio. Lewis Research Center). Sept. 1969. 30p. (NASA-TN-D-5407). CFSTI.

Spiraling in ion–molecule collisions with polarizable and/or polar targets is investigated numerically using computer plotting techniques. Collision orbits and interaction behavior are studied for a range of collision parameters on the IBM 360/67 and 7094 computers with the CDC DD280 plotter. Multiple reflections off a hard-core barrier at small ion–molecule separations occur only in collisions with permanent dipoles. Multiple reflection times for 2 to 2000 reflections are 10 to $10^3$ times longer than times for single reflections. Long multiple reflection collision times, however, do not mean large capture cross sections; the capture cross section values are much less than those predicted by the adiabatic theory. (auth) (STAR)

**17655** (N-69-38773) SURVEY OF ELECTRON–CESIUM COLLISION PROBABILITIES: MOMENTUM TRANSFER COLLISIONS. Dayton, James A. Jr. (National Aeronautics and Space Administration, Cleveland, Ohio. Lewis Research Center). Oct 1969. 20p. (NASA-TM-X-1897; E-5154). CFSTI.

A comprehensive collection of the experimental and theoretical values of the electron–cesium atom probability of collision for momentum transfer at electron energies up to 2.0 eV is presented. It was found that a considerable lack of agreement exists, with regard not only to the magnitude of the collision probability at a given energy, but also to the position (even the existence) of minima and maxima. Qualified recommendations of the correct values are offered. (auth) (STAR)

**17656** (N-70-10626) EXCITATION OF ATOMIC HYDROGEN TO THE METASTABLE $2\,^2S_{\frac{1}{2}}$ STATE BY ELECTRON IMPACT. Kauppila, W. E.; Ott, W. R.; Fite, W. L. (Pittsburgh Univ., Pa. Space Research Coordination Center). 16 Sep 1969. 33p. (NASA-CR-106653; SRCC-102). CFSTI.

The cross section for excitation of atomic hydrogen to the $2\,^2S_{\frac{1}{2}}$ state by electron impact was remeasured in a modulated crossed-beam experiment in the energy range extending from threshold to 1000 eV. Absolute values for the 2S cross section were obtained by measuring the ratio of the 2S to 2P cross sections and using previous measurements of the 2P cross section, which were normalized to the Born approximation at high energies. The atoms excited to the 2P and 2S states were detected by observing the Lyman-alpha photons produced by radiative decay and by quenching in an electrostatic field, respectively. In order to determine the total cross section, it was necessary to consider the polarization of the Lyman-alpha radiation emitted in each method of detection. The remeasured cross section is found to be in agreement with the Born approximation above 200 eV. The measured ratios are in reasonable agreement with the ratios that would be predicted by the close-coupling theory of Burke et al. (auth) (STAR)

**17657** (N-70-10707) POLARIZATION OF LYMAN ALPHA RADIATION EMITTED IN ELECTRON COLLISIONS WITH HYDROGEN ATOMS AND MOLECULES. Ott, W. R.; Kauppila,

W. E.; Fite, W. L. (Pittsburgh Univ., Pa. Dept. of Physics). 16 Sep 1969. 34p. (NASA-CR-106647; SRCC-103). CFSTI.

The polarizations of Lyman-alpha radiation produced by electron impact on atomic and molecular hydrogen, and by electric-field quenching of metastable 2S hydrogen atoms were measured. The polarization analyzer was a lithium fluoride crystal set at the Brewster's angle, with reflected radiation being detected by an iodine vapor photon counter. Generally good agreement between measured polarization fractions and recent theoretical predictions was found. The radiation produced by quenching metastable atoms in an electron field was found to be polarized with a polarization fraction of $-0.30$ + or $-0.02$, which compared with the theoretical value of $-0.323$. (auth) (STAR)

17658 (N-70-11503) INNER SHELL IONIZATIONS BY PROTON IMPACT. Garcia, J. D. (Arizona Univ., Tucson. Dept. of Physics). [1968]. 25p. (NASA-CR-106833). CFSTI.

Cross sections for production of inner-shell vacancies in atoms by proton impact were examined in an impulse approximation. The model used includes modifications to account for the nuclear repulsion of the proton. Comparisons with experiment and with other calculations are made. It is found that the model compares favorably with existing Born approximations. If the most recent fluorescent yield data are used, the present results agree well with experiment for proton energies larger than approximately 300 times the electron binding energies. Determination of fluorescent yields by means of such experiments is also discussed. (auth) (STAR)

17659 THEORETICAL METHODS OF CALCULATION OF EXCITATION CROSS SECTIONS OF TWO-ELECTRON SYSTEM BY ELECTRON IMPACT. Lee, Edward Tak-Ping. Norman, Okla.; Univ. of Oklahoma (1969). 140p.

Thesis.

The intensity of the 4686-Å radiation was measured. The radiation is due to the simultaneous ionization and excitation of helium by electron impact and subsequent decay: ($He^+$, $n = 4 \rightarrow n = 3$). The first part of the thesis is devoted to a calculation of the cross sections of ($He^+$,4P) and ($He^+$,4D). The cross section of ($He^+$,4F) is estimated. From the direct ionization–excitation cross sections and the branching ratios the intensity of the 4686-Å line can be predicted. The cascade contribution is estimated to be less than 4% and hence negligible. The radiation ($He^+$,4S $\rightarrow$ 3P) constitutes about 90% of the theoretical intensity of the 4686-Å. In spite of the approximations involved, the agreement between the calculated and the experimental values is reasonably good. The calculation is extended to the 3203-Å ($n = 5 \rightarrow n = 3$), 2733-Å ($n = 6 \rightarrow n = 3$), and 2511-Å ($N = 7 \rightarrow n = 3$) lines. In the second part of the thesis the excitation cross section of Hg is calculated. The excited states of interest are $7^1S_0$, $6^3D_1$, $6^1D_2$, $7^3P_2$. Born and Born–Oppenheimer approximations are used. Also cross sections by Ochkur's formula are obtained. The calculated values are then compared with Anderson's measurements. The purpose of the last part of the thesis is to make a first principle calculation of the polarization potential and the vibrational excitation cross section of $H_2$. Cross sections are obtained by the Born approximation and also by close coupling formulation. It is concluded that quantum mechanical calculation of the vibrational excitation cross section of $H_2$ by electron impact produces results that agree with experiment provided that the polarization potential is taken into account in sufficient detail. (TSS) (Diss. Abstr. Int., B)

17660 FORMATION OF HIGHLY EXCITED ATOMS IN THE CHARGE-EXCHANGE PROCESS. Solov'ev, E. S.; Il'in, R. N.; Oparin, V. A.; Serenkov, I. T.; Fedorenko, N. V. (Ioffe Inst. of Physics and Tech., Leningrad). JETP Lett. (USSR) (Engl. Transl.); 10: 190-2(5 Oct 1969).

Translated from Zh. Eksp. Teor. Fiz. Pis'ma Redaktsiyu; 10: 300-3(5 Oct 1969).

The formation of highly excited atoms of He, N, O, and Ne during the process of charge exchange of fast $He^+$, $N^+$, $O^+$, and $Ne^+$ ions in Mg vapor and the distinguishing features of their ionization by an electric field were studied. The ratio I of the number of atoms ionized in the field E to the total atom flux was measured and was found to be proportional to $\sqrt{E}$. The production of highly excited He atoms by charge exchange of 30- to 180-keV $He^+$ ions with Ne, Na, or Mg atoms was studied in greater detail. The cross section was found to be maximal when the ion velocity was equal to the velocity of the outer electron in the target atom. The differential relation dI/dE was also studied and compared to that for hydrogen. (A.G.W.)

17661 THE MECHANISM OF THE IONIC–MOLECULAR REACTION INVOLVED IN THE FORMATION OF $D_3H^+$. Ivanov, V. V.; Kaminskii, V. A.; Tikhomirov, M. V.; Tunitskii, N. N. (Karpov Physico-Chemical Inst., Moscow). Khim. Vys. Energ.; 3: 539-40(Nov-Dec 1969). (In Russian).

Ionic molecular reactions may occur by the formation of an intermediate complex that is subsequently decomposed (statistical mechanism), or by direct interaction. In the latter case the differential cross section depends strongly on the emission angle of the reaction products. This problem was examined by using molecular ions with various degrees of vibratory excitation and comparing the results obtained with different isotopically substituted molecules. $H_2^+$ and $D_2^+$ ions obtained by electron collision from $CH_4$ and $CD_4$ and from $H_2$ and $D_2$, respectively were used for the study. The following reactions were examined by mass spectrometry: $H_2^+(H_2) + D_2 \rightarrow D_2H^+ + H$ (Ia), $H_2^+(CH_4) + D_2 \rightarrow D_2H^+ + H$ (Ib), $D_2^+(D_2) + H_2 \rightarrow D_2H^+ + H$ (IIa), $D_2^+(CD_4) + H_2 \rightarrow D_2H^+ + H$. It was found that the increase of the vibratory excitation energy of $H_2^+$ in (Ia) results in the increase of the cross section of formation of $D_2H^+$: $\sigma_{Ib}/\sigma_{Ia} \cong 2.0$. On the other hand, an increase of the vibrational excitation of $D_2^+$ in reactions (IIa) and (IIb) affects only slightly the cross section. These results cannot be explained by the statistical mechanism but the direct reaction may be invoked for the transfer of proton or hydrogen atom. (TTT)

17662 MEASURING ABSOLUTE MAGNITUDES OF THE APPARENT CROSS SECTION FOR CALCIUM IONIZATION BY MEANS OF ELECTRON IMPACT. Rakhovskii, V. I.; Stepanov, A. M. (Inst. of High Temperature, Moscow). Teplofiz. Vys. Temp.; 7: 1071-4(Nov-Dec 1969). (In Russian).

A crossed-beam method was used for determining the absolute magnitude of ionization cross sections of calcium from the ionization threshold to 200 eV with monoenergetic 0.35- to 0.5-eV electrons. Two maxima, 6.4 $Å^2$ at 20 eV and 7.0 $Å^2$ at 29 eV, were observed. Accuracy of measurements of the cross sections was 24%. Data obtained are correlated with published data. (tr-auth)

17663 ATOMIC COLLISION PROCESSES. Eleventh Boulder Summer Institute for Theoretical Physics, Boulder, Colorado, June 17–August 23, 1968. Geltman, Sydney; Mahanthappa, Kalayana T.; Brittin, Wesley E. (eds.). Lectures in Theoretical Physics, Volume XI-C. New York; Gordon and Breach, Science Publishers, Inc. (1969). 345p. (CONF-680842-(Pt.4)).

Separate abstracts were prepared for eight of the ten lectures included. The two lectures not abstracted were on scattering theory of absorption- and autoionization-line profiles and on optical pumping theory. (A.G.W.)

*For abstracts of individual sections see: 17664–17670 and 17934.*

17664 LOW ENERGY ELECTRON–ATOM SCATTERING. Burke, P. G. (Queen's Univ., Belfast). Lect. Theor. Phys.; 11-C: 1-55(1969).

From Conference on Atomic Collision Processes, Boulder, Colo. See Conf-680842-(Pt.4).

In a review of the theory of electron–atom scattering, an expansion for the cross section in terms of the asymptotic form of the wave function is derived. It is shown how the wave function can be obtained from a variational principle. The close-coupling approximation used to describe electron–atom collisions is introduced and some examples of its application are pointed out. The effects of the long-range electron–atom potential and methods developed to include this potential are considered. The concept of the optical potential is introduced. The effective range theory of electron–atom collisions is developed. Emphasis is on the way this theory is modified by the long-range potentials. Electron–atom resonance theory and some examples and applications are discussed briefly. (87 references). (A.G.W.)

17665 REQUIREMENTS FOR THE EXISTENCE OF BOUND STATES. Spruch, Larry (New York Univ., N. Y. Joint Inst. for Lab. Astrophysics, Boulder, Colo.). Lect. Theor. Phys.; 11-C: 57-75(1969).

From Conference on Atomic Collision Processes, Boulder, Colo. See Conf-680842-(Pt.4).

Results obtained on necessary conditions for the existence of bound states is summarized. Problems involved in finding upper and lower bounds on the number of bound states that can be formed by a particle and a target or in proving that no bound state can exist are considered. The trace technique, the integral equation, and the adiabatic approximation are discussed briefly. (19 references) (A.G.W.)

17666 VARIATIONAL UPPER AND LOWER BOUNDS ON TRANSITION AMPLITUDES. Spruch, Larry (New York Univ., N. Y. Joint Inst. for Lab. Astrophysics, Boulder, Colo.). Lect. Theor. Phys.; 11-C: 77-94(1969).

From Conference on Atomic Collision Processes, Boulder, Colo. See Conf-680842-(Pt.4).

Upper and lower variational bounds on the transition amplitudes induced in a quantum mechanical system by an external space- and time-dependent potential of arbitrary strength are obtained; the wave functions of the initial and final states of the transition are assumed to be known. Examples include transitions induced in an atom by a laser pulse, whether one or more photons are required for the transition to proceed, or transitions induced in an atom–atom collision in which the semiclassical approximation of treating the positions of each of the nuclei as prescribed functions of time is made. (A.G.W.)

**17667** ELASTIC AND INELASTIC ATOM–ATOM SCATTERING. Smith, Felix T. (Stanford Research Inst., Menlo Park, Calif.). Lect. Theor. Phys.; 11-C: 95-117(1969).

From Conference on Atomic Collision Processes, Boulder, Colo. See Conf-680842-(Pt.4).

The use of some semiclassical procedures to describe atom–atom or atom–ion scattering, where the masses and energies usually involved justify the classical approximation, and where the particles are sufficiently simple that spherically symmetric force laws often suffice, is examined. It is concluded that, in the case of inelastic scattering, classical mechanics represents an important limiting case and often a very good approximation. Certain aspects of inelastic scattering cannot be described by strictly semiclassical methods because the inelastic process always involves electronic transitions, but some semiclassical procedures are useful and deserving of amplification and improvement. (18 references) (A.G.W.)

**17668** INELASTIC ATOM–ATOM COLLISIONS. Callaway, Joseph (Louisiana State Univ., Baton Rouge). Lect. Theor. Phys.; 11-C: 119-37(1969).

From Conference on Atomic Collision Processes, Boulder, Colo. See Conf-680842-(Pt.4).

Application of the eikonal approximation to description of atom–atom collisions involving excitation (or de-excitation) without rearrangement, such as $A + B \rightleftharpoons A^* + B^*$, is reviewed. Some possible improvements are suggested, and the relative merits of some alternate procedures (including first-order perturbation theory, the unitary approximation, and the Landau–Zener formula) are compared. (17 references) (A.G.W.)

**17669** REARRANGEMENT COLLISIONS. Bransden, B. H. (Univ. of Washington, Seattle). Lect. Theor. Phys.; 11-C: 139-92(1969).

From Conference on Atomic Collision Processes, Boulder, Colo. See Conf-680842-(Pt.4).

Approximations that might be expected to be accurate for calculating the scattering amplitude for rearrangement collisions in the high-energy region are discussed. After a brief review of the general theory of collisions and the three-body problem, consideration is given to each of the following: the Born approximation, distorted wave approximations, the Bonham–Ochkur approximation, the two-state approximation, a one-dimensional model, the impulse approximation, and McCarrol and Salin's approximation. The various approximations are then compared with experimental results on charge-exchange reactions, electron scattering, and positronium reactions. (55 references) (A.G.W.)

**17670** PHOTOELECTRON ANGULAR DISTRIBUTIONS. Cooper, J.; Zare, R. N. (Univ. of Colorado, Boulder). Lect. Theor. Phys.; 11-C: 317-37(1969).

From Conference on Atomic Collision Processes, Boulder, Colo. See Conf-680842-(Pt.4).

The calculation of photoelectron angular distributions for one-electron systems is reviewed, and the results are extended to many-electron systems. Other possible extensions of these results are considered briefly; these include higher-order multipoles, electron and heavy-particle impact ionization, polarization of atomic emission accompanying photoelectron ejection, multiphoton processes, and molecular photoionization and photodetachment. (21 references) (A.G.W.)

**17671** FIRST BORN APPROXIMATION ELECTRON LOSS, IONIZATION, AND TOTAL ELECTRON PRODUCTION CROSS SECTIONS FOR FAST POSITIVE HELIUM IONS INCIDENT ON ATOMIC HELIUM. Bell, K. L.; Dose, V.; Kingston, A. E. (Queen's Univ., Belfast). J. Phys., B (London); 3: 129-37(Feb 1970).

The first Born length and velocity approximation is used to calculate cross sections for one-electron loss, total electron production, and ionization occurring in the collision of fast singly ionized helium with neutral atomic helium. Account is taken of double transitions. Good agreement between the theoretical and experimental values of the one-electron loss, total electron production, and ionization cross sections is found for impact energies greater than 1000, 300, and 300 keV, respectively. (auth) (UK)

**17672** DIFFERENTIAL CROSS SECTIONS IN PROTON–HYDROGEN COLLISIONS. McCarroll, R.; Piacentini, R. D.; Salin, A. (Observatoire de Paris, Meudon, France). J. Phys., B (London); 3: 137-48(Feb 1970).

The two-state atomic-orbital expansion with variable effective charge is used to compute the variation with energy E and angle $\theta$ of the charge-exchange probability in $H^+ - H$ collisions. The agreement with the experimental results of Helbig and Everhart (1965) is astonishingly good. Estimates are also made of the range of validity of the adiabatic approximation; considerable deviation from adiabatic conditions is found for $E\theta > 1$ keV deg. (auth) (UK)

**17673** IONIZATION OF $Li^+$ AND $Mg^+$ BY ELECTRON IMPACT. Moores, D. L.; Nussbaumer, H. (University Coll., London). J. Phys., B (London); 3: 161-73(Feb 1970).

Cross sections for the single ionization of $Li^+$ and $Mg^+$ by electron impact are calculated in the Coulomb–Born approximation (neglecting exchange), and compared with recent experimental results. In the case of $Li^+$ it is shown that the Bethe–Born approximation is not valid until the incident electron energy is much greater than previously supposed. For $Mg^+$, it is shown that ionization from inner shells provides an important contribution to the cross section. Contributions from autoionization are also shown to be significant but do not introduce large irregularities in the total cross section. (auth) (UK)

**17674** CHANNEL COUPLING AND ATOMIC POLARIZATION IN ELECTRON COLLISIONS WITH HYDROGEN ATOMS. Mohr, C. B. O. (Univ. of Melbourne). J. Phys., B (London); 3: 177-82(Feb 1970).

The changes in the partial-wave phase shifts for the elastic scattering of 26- and 52-eV electrons by hydrogen, which are produced by coupling of the ground state to the 2s and the 2p states, are calculated. For this purpose some approximations used in a previous paper are improved. The changes in phase shifts are compared with those produced by the inclusion of a polarization potential. In the energy range considered, it is found that channel coupling gives results markedly different from those given by the polarization potential. (auth)

**17675** CLOSURE APPROXIMATION FOR EXCITATION OF ATOMIC HYDROGEN BY PROTON IMPACT. Catlow, G. W.; McDowell, M. R. C.; Cheshire, I. M. (Durham Univ., Eng.). J. Phys., B (London); 3: 183-90(Feb 1970).

Cross sections for the excitation of atomic hydrogen by proton impact into the 2s state are calculated using the closure approximation of Cheshire (1965). No experimental results are available so comparison is made only with other calculated cross sections. (auth) (UK)

**17676** FORMATION OF $He^-$ IONS IN COLLISIONS INVOLVING 80- TO 200-keV HELIUM METASTABLE ATOMS IN HYDROGEN. Gilbody, H. B.; Dunn, K. F.; Browning, R. (Queen's Univ., Belfast). J. Phys., B (London); 3: L19-21(Feb 1970).

The formation of $He^-$ ions in collisions involving one-electron capture by fast metastable helium atoms in hydrogen was studied experimentally. In the energy range 80 to 200 keV lower bounds on the cross section $\sigma_{\theta^{*1}}$ were obtained, which are about an order of magnitude greater than the only previous estimates of the $He^-$ formation cross sections. (auth) (UK)

**17677** SINGLE AND DOUBLE EXCITATIONS IN HYDROGEN–HYDROGEN COLLISIONS. Flannery, M. R.; Levy II, H. (Smithsonian Astrophysical Observatory, Cambridge, Mass. Harvard Coll. Observatory, Cambridge, Mass.). J. Phys., B (London); 3: L21-3(Feb 1970).

The influence of the long-range quadrupole coupling between the single- and double-excitation channels in hydrogen–hydrogen collisions is examined and found to be ineffective, owing to the relatively large energy defect existing between the channels. (auth) (UK)

**17678** REMEASUREMENT OF THE CROSS SECTION FOR CHARGE EXCHANGE IN $H^+$–$H^-$ COLLISIONS. Gaily, T. D.; Harrison, M. F. A. (Culham Lab., Abingdon, Eng.). J. Phys., B (London); 3: L25-6(Feb 1970).

The cross section for charge exchange in $H^+ - H^-$ collisions was remeasured in the energy range 0.6 to 4 keV using a modified version of the original apparatus. Earlier results are confirmed, lending increased confidence to the measurement. (auth) (UK)

**17679** EXCITATION OF SINGLY IONIZED BARIUM IONS BY ELECTRON IMPACT. Davis, J. (Ion Physics Corp., Burlington, Mass.); Morin, S. Can. J. Phys.; 48: 275-8(1 Feb 1970).

Cross-section calculations for excitation of singly ionized barium ions by electron impact over the energy range from 3 to

100 eV are presented. The cross sections were evaluated using Burgess' semiclassical method. Finally, predictions are compared with two other current techniques and some recent experimental measurements. The agreement was found to be good. (auth)

**17680** LYMAN-$\alpha$ EXCITATION AND RESONANT CHARGE EXCHANGE IN SLOW $H^+-H(1s)$ COLLISIONS. Knudson, Stephen K. (Massachusetts Inst. of Tech., Cambridge); Thorson, Walter R. Can. J. Phys.; 48: 313-29(1 Feb 1970).

The dominant processes in slow collisions (E < 0.5 keV) of protons and 1s hydrogen atoms are direct elastic scattering, resonant charge exchange, and direct and exchange excitations of H(2p). Differential cross sections were calculated for all these events by both quantal and classical methods, and characteristics of the resulting Lyman-$\alpha$ (Ly-$\alpha$) radiation determined. Significant differences from earlier calculations are found for excitation probability, polarization of Ly-$\alpha$, and the interference oscillations in the charge-exchange probability. The phase of the latter is a sensitive function of the interactions causing inelastic scattering. The source of discrepancy with earlier results is the use of the impact-parameter approximation (straight-line trajectories); over the range of significant excitation probability, classical path methods using true trajectories give accurate inelastic parameters. Comparison of quantal and classical calculations shows that accurate results for all properties discussed can be obtained by combining classical path calculations of inelastic parameters with semiclassical phase shifts for pure elastic scattering. If polarizations calculated here are used to reinterpret earlier observations of Ly-$\alpha$ emission from 300-eV collisions, the resulting experimental cross sections are not inconsistent with the basic theoretical prediction of equal direct and exchange excitation probabilities. (auth)

**17681** APPLICATION OF FREDHOLM THEORY TO ELASTIC SCATTERING. Moiseiwitsch, B. L.; O'Brien, T. J. (Queen's Univ., Belfast). J. Phys., B (London); 3: 191-8(Feb 1970).

The Fredholm expansion method is used to evaluate the S-wave phase shifts for: (i) the elastic scattering of electrons by (a) the static potential of atomic hydrogen, (b) a hydrogen atom, with exchange taken into account by the use of symmetrized wave functions; (ii) the elastic scattering of particles by exponential and screened Coulomb potentials. It is found that, whereas the Born series often converges slowly even at quite high impact energies, the Fredholm expansion usually converges fairly rapidly to the exact value of the phase shift. In the cases investigated the second Fredholm approximation is superior to the second Born approximation except sometimes at low impact energies. However, it should be noted that the first Fredholm approximation is usually much inferior to the first Born approximation at all impact energies and so should not be used. (auth) (UK)

**17682** DIFFERENTIAL MEASUREMENTS ON ION–ATOM COLLISIONS IN THE ENERGY RANGE 500 eV TO 3000 eV. III. $Ne^+$ ON Ne, $Ar^+$ ON Ar AND $Kr^+$ ON Kr COLLISIONS. Barat, M.; Baudon, J.; Abignoli, M.; Houver, J. C. (Faculte des Sciences, Orsay, France). J. Phys., B (London); 3: 230-51(Feb 1970).

Elastic and inelastic differential cross sections were measured in relative values for the symmetrical ion–atom collisions: $Ne^+$ on Ne, $Ar^+$ on Ar, and $Kr^+$ on Kr, in the energy range 500 to 3000 eV and in the angular range 0.5° to 13° (lab). Three types of processes were observed: elastic, excitation on discrete levels, and excitation of the atom on autoionizing levels. The elastic differential cross section shows a double oscillation due to the interference of the $\Sigma$ or $\Pi$ states of the system. This feature is studied in detail in the case of the $Ne^+-Ne$ system for which the calculated cross section is compared to the experimental one. Rather good agreement is found between them, except for the violent collisions, for which a strong absorption appears in the elastic channel. In the case of the $Ar^+-Ar$ collision this absorption gives diffraction effects. The excitation processes are dominated by the crossings of the nonadiabatic potential curves. The locations of these crossings were determined for the $Ne^+-Ne$ and $Ar^+-Ar$ collisions and they are compared to the locations of the crossings of potential curves deduced from the MO energies of $Ne_2$ or $Ar_2$, by use of the Koopmans' rule. The reduced differential cross sections for the excitation of the atom on autoionizing levels present a maximum at a given value of the distance of closest approach, which corresponds to a crossing of a ground-state potential branch and an autoionizing-state potential curve. (auth) (UK)

**17683** DIFFERENTIAL MEASUREMENTS ON ION–ATOM COLLISIONS IN THE ENERGY RANGE 500 eV TO 3000 eV. II. $He^+$ ON Ne, Ar, Kr, Xe, AND $Ne^+$ ON He COLLISIONS. Baudon, J.; Barat, M.; Abignoli, M. (Faculte des Sciences, Orsay, France). J. Phys., B (London); 3: 207-29(Feb 1970).

Elastic and inelastic differential cross sections were measured in relative values for asymmetrical rare-gas-ion–rare-gas-atom systems, in the energy range 500 to 3000 eV and in the angular range 0.5° to 13° (in the laboratory frame). The systems under investigation are: $He^+$ on other rare gas atoms and $Ne^+$ on He. Three types of collision processes are considered: elastic, excitation on discrete states, and excitation of the atom in autoionizing levels. The $He^+-Ne$ system is discussed in detail and compared to the inverse system $Ne^+-He$. The excitation processes are dominated by the crossings of the nonadiabatic potential curves. The locations of the crossings were determined for the $He^+-Ne$ system and for the $Ne^+-He$ system. At large values of $r$, transitions toward several inelastic channels are to be considered; a rough calculation of the inelastic cross section is given in the case of an almost continuous series of crossings. The reduced differential cross sections for the excitation of the atom on autoionizing levels present generally a maximum at a value of $r$ independent of energy, i.e., at a given value of the internuclear distance, which suggests the intervening of a curve crossing. (auth) (UK)

**17684** EXCITATION OF SINGLET AND TRIPLET HELIUM LEVELS BY $H^+$, $H_2^+$, $H_3^+$ AT INTERMEDIATE ENERGIES. Grouard, Jean-Pierre; Hirszowski, Julien; Lefebure, Patrick; de Palmas, Henri (Paris Univ.). Compt. Rend., Ser. B; 270: 264-7(26 Jan 1970). (In French).

Relative excitation cross sections of the $3\ ^1P$, $3\ ^3D$, $4\ ^3D$, $4\ ^3S$ helium levels by $H^+$, $H_2^+$, and $H_3^+$ were measured in the energy range 15 to 40 keV. (France)

**17685** CALCULATION OF ANISOTROPIC PHOTOIONIZATION CROSS SECTIONS. I. HYDROGEN ATOM. Lin, Sheng Hsien (Arizona State Univ., Tempe). Can. J. Phys.; 46: 2719-32 (15 Dec 1968).

The differential and total cross sections of photoionization of the hydrogen atom from the states 1s, 2s, $2p_m$, $3p_m$, $3d_m$, and $4d_m$ are calculated for the photoelectron kinetic energy E from E = 0.01 atomic unit to E = 2.00 atomic unit. It is found that when the magnetic sublevels of the initial state are equally populated, the angular distribution of photoelectrons has the behavior $\sigma = 1/4\pi\ Q[1 + \beta P_2(\cos\theta)]$, and, besides 1s and 2s states, the angular distribution of photoelectrons from np state, nd state, etc. will become isotropic at a particular photoelectron kinetic energy. The angular distribution of photoelectrons for the case in which the magnetic sublevels of the initial bound state are unequally populated is also discussed. (auth) (Canada)

**17686** FAST DETERMINATION OF RESONANCE STATES IN ATOMIC COLLISIONS. Jackson, James L.; Wyatt, Robert E. (Univ. of Texas, Austin). Chem. Phys. Lett.; 4: 643-5(1 Feb 1970).

Two new criteria for the prediction of a resonance state are proposed and compared with previous criteria. Numerical comparisons are presented for the l = 50 states of OH ($X^2\Pi_i$). (auth)

**17687** THEORY OF THE FORWARD PEAK IN THE ANGULAR DISTRIBUTION OF ELECTRONS EJECTED BY FAST PROTONS. Macek, Joseph (Univ. of Nebraska, Lincoln). Phys. Rev., A; 1: 235-41(Feb 1970).

The cross section for ejecting electrons by 300-keV protons is calculated using the first term in the Neuman expansion of Faddeev's equation for the final state of the electron–proton–residual ion system. This approximation predicts a peak at 0° in the angular distribution of electrons ejected with a velocity approximately equal to the velocity of outgoing protons. Numerical results for He and $H_2$ target gases are given and compared with the experiments of Rudd and co-workers. The qualitative behavior of the forward peak in the experimental angular distributions is well accounted for. (auth)

**17688** PRODUCTION AND LOSS OF FAST METASTABLE HELIUM ATOMS IN COLLISIONS WITH PERMANENT GASES. Miers, R. E.; Anderson, L. W. (Univ. of Wisconsin, Madison). Phys. Rev., A; 1: 534-5(Feb 1970).

Cross sections for production and destruction of fast $He^0$ atoms in triplet states were measured for 10- to 30-keV $He^+$ ions incident on gas targets of Kr, $N_2$, and Ne. Values of the fractions of neutral $He^0$ atoms in the triplet metastable state emerging from thin targets of Kr, $N_2$, and Ne are 0.12 ± 0.005, 0.06 ± 0.03, and 0.03 ± 0.02, respectively, for incident $He^+$ energies of 30 keV. (auth)

**17689** STRUCTURES IN THE LOW-ENERGY $e^-$–He SCATTERING CROSS SECTIONS. Golden, D. E.; Zecca, A. (Univ., Bari, Italy). Phys. Rev., A; 1: 241-9(Feb 1970).

A cylindrical, retarding potential difference type of electron spectrometer with high-energy resolution was used to study the

structures in the $e^- - He$ scattering cross section in a transmission experiment. Twenty-four structures were observed between the transmission maximum due to $He^- 1s2s^2\ ^2S_{\frac{1}{2}}$ at 19.30 ± 0.01 eV and $He^+ 1s^2S_{\frac{1}{2}}$ at 24.60 ± 0.02 eV, 11 of which have been observed previously. The agreement with previous measurements for the positions of the structures is good where comparison is possible. Four of the new structures were observed below the n = 2 states of He. The excitation onsets for $2^3S_1$, $2^1S_0$, $2^3P^0$, and $2^1P^0$ were observed, as well as some excitation onsets at higher energies. No structures were observed below $He^-\ ^2S_{\frac{1}{2}}$. Two structures were observed above $He^+\ ^2S_{\frac{1}{2}}$, which were observed previously. (auth)

**17690** ELECTRON-IMPACT IONIZATION OF He($2s^3S$). Long, Daniel R.; Geballe, Ronald (Univ. of Washington, Seattle). Phys. Rev., A; 1: 260-5(Feb 1970).

The absolute electron-impact ionization cross section of the metastable He($2s^3S$) state of helium was measured by the application of a double-electron-beam technique. The cross section at the plateau is about $6.5 \times 10^{-16}$ cm² ±30%. The ionization of the metastable He($2s^1S$) state of helium was also observed. The absolute ionization-cross-section measurement is in good agreement with the experimental results for lithium and with the theories for H(2s) when compensation for the differing ionization potentials is made. (auth)

**17691** INNER-SHELL IONIZATION BY PROTON IMPACT. Garcia, J. D. (Univ. of Arizona, Tucson). Phys. Rev., A; 1: 280-5(Feb 1970).

Cross sections for production of inner-shell vacancies in atoms by proton impact were examined in an impulse approximation. The model used includes modifications to account for the nuclear repulsion of the proton. Comparisons with experiment and with other calculations are made. It is found that the model compares favorably with existing Born approximations. If the most recent fluorescent-yield data are used, the present results agree well with experiment for proton energies larger than ~300 times the electron binding energies. Determination of fluorescent yields by means of such experiments is also discussed. (auth)

**17692** ANGULAR DISTRIBUTION OF FAST ELECTRONS EJECTED FROM K AND L SHELLS BY PROTON IMPACT. Choi, Byung-Ho; Merzbacher, Eugen (Univ. of North Carolina, Chapel Hill). Phys. Rev., A; 1: 299-304(Feb 1970).

Time-dependent perturbation theory is used to evaluate the angular distribution of electrons emitted from heavy atoms in collisions with protons and other heavy charged particles. The incident particle is assumed to move on a straight-line trajectory. Hydrogenic wave functions are used for the initial electron state, and continuum Coulomb wave functions for the final electrons. The angular distributions of electrons emitted from K and L shells by a given projectile are compared. The separate contributions of the L subshells to the angular distributions are also calculated. (auth)

**17693** CROSS SECTION FOR METASTABLE PRODUCTION IN LOW-ENERGY $He^+$–He COLLISIONS. MacVicar-Whelan, P. J.; Borst, W. L. (Univ. of California, Berkeley). Phys. Rev., A; 1: 314-18(Feb 1970).

Metastable He atoms produced by charge exchange of slow $He^+$ with He were detected by secondary electron emission from a tungsten target. The cross section for metastable production rose from a threshold near 22 eV to a peak value of $2.2 \times 10^{-18}$ cm² ±50% at 27 eV and decreased to a minimum at 32 eV (center-of-mass energy). A subsequent rise was measured up to 110 eV and was attributed to the increased production of $He^m$ and, to a smaller extent, to kinetic emission of secondary electrons at the higher energies. (auth)

**17694** ELECTRON-IMPACT EXCITATION OF $Be^+$, $Mg^+$, AND $Ca^+$ IONS. Tripathi, A. N.; Mathur, K. C.; Joshi, S. K. (Univ. of Roorkee, India). Phys. Rev., A; 1: 337-40(Feb 1970).

The classical binary-encounter model for the ionization of ions by impact of electrons given by Thomas and Garcia was extended to calculate the excitation cross section of ions. The electron-impact excitation cross sections for the 3s–3p and the 3s–3d transition in $Mg^+$, the 2s–2p transition in $Be^+$, and the 4s–4p transition in $Ca^+$ were calculated. The results are compared with calculations based on the close-coupling and the Coulomb–Born approximations. Our results agree better with close-coupling calculations than with calculations based on the Coulomb–Born approximation. (auth)

**17695** SIMULTANEOUS PHOTOIONIZATION AND PHOTOEXCITATION OF HELIUM. Brown, Robert L. (National Radio Astronomy Observatory, Green Bank, W. Va.). Phys. Rev., A; 1: 341-7(Feb 1970).

A general method is presented for calculating the f values for all permitted dipole transitions involving simultaneous photo-ionization and photoexcitation of helium. The cross section for ions excited into the n = 2 state is compared with experiment and with a similar calculation by Salpeter and Zaidi; their result, that the ejected electron is in a p state is confirmed. The probability for the residual $He^+$ ion to be excited to a state of principal quantum number n is evaluated for n = 2 to 10, and the probability for the photoelectron to be in a p state is compared with the probability for it to be emitted in an s state. It is found that the inclusion of contributions from simultaneous photo-ionization and photoexcitation, and from double ionization in the total helium photo-ionization cross section, improves the agreement between theory and the experimental data at high energies. (auth)

**17696** OSCILLATORY STRUCTURE IN TOTAL-CHARGE-TRANSFER CROSS SECTIONS. Perel, Julius (Electro-Optical Systems, Pasadena, Calif.). Phys. Rev., A; 1: 369-75(Feb 1970).

Oscillatory structure has been observed in total symmetric and asymmetric charge-transfer cross-section measurements involving the alkali-metal atoms. Cross sections with oscillations similar to experimental results had been obtained from impact-parameter calculations using a two-state approximation with an interaction potential difference containing a maximum. This paper describes a physical model of charge transfer relating to the oscillatory electron-capture probability. The $Li^+ + Li$ calculations of Peek et al., are examined and used as an example to relate capture-probability oscillations to those in total cross sections. Computed capture probabilities having anomalous oscillations are shown as a function of impact parameter at several velocities. The capture-probability maxima are shown as contours on a plot of impact parameter versus inverse impact velocity. This plot illustrates capture-probability oscillations having a nearly stationary phase over a range of impact parameters, which results in oscillations in the total cross section. Oscillation damping and phase-constant effects are briefly examined to relate experimental results with theory. Near-resonant asymmetric oscillations are also discussed. (auth)

**17697** COMMENTS ON THE CALCULATION OF RELATIVISTIC BREMSSTRAHLUNG CROSS SECTIONS. Tseng, H. K.; Pratt, R. H. (Univ. of Pittsburgh). Phys. Rev., A; 1: 528-31 (Feb 1970).

Recent attempts to calculate relativistic bremsstrahlung cross sections in the intermediate energy region are discussed, using results from an independent exact numerical calculation. The numerical work of Brysk, Zerby, and Penny gives quite good results for the bremsstrhlung cross section differential only in photon energy, but significantly underestimates and overestimates the cross section differential in photon energy and angle, in small-photon-angle regions and in large-photon-angle regions, respectively. The approximate analytical results of Elwert and Haug are quite good for low atomic number Z, but deviations appear for Z = 13. For Z = 79, their theory underestimates the cross section by large factors. (auth)

**17698** ELASTIC SCATTERING BY A SINGULAR POTENTIAL. Cao-xuan-Chuan; Ho-van-Hoa (Faculte des Sciences, Saigon, Vietnam). Compt. Rend., Ser. B; 269: 732-5(20 Oct 1969). (In French).

Several results are established concerning elastic scattering by a singular potential of the type $V(r) = A_n/r^n$, n being any value. These results, obtained in the framework of statistical mechanics, are usable in certain problems of atomic physics. (tr-auth)

## *Atomic Theory*

**17699** (AD-693935) PARTIAL EXCITATION: SECOND REPORT. Report on Quantum Theory. Deer, James W. (Electronic Specialty Co., Portland, Oreg. Electronics Div.). 25 Sep 1969. 28p. CFSTI.

Further development is given of a previous theory of partial excitation (AD-683 388). It is shown that the Schrödinger wave equation results from properties of the Maxwell–Lorentz–Schrödinger field. This latter is obtained by fusion of the Schrödinger amplitude into the Maxwell–Lorentz equations. Partex (partial excitation theory) gives a different value of energy for the ground state of the hydrogen atom, as compared to quantum mechanics. This is because partex does not involve use of reduced electronic mass in calculation of the ground-state energy. In this theory the electronic charge cloud has no particle-like aspect. (auth) (USGRDR)

**17700** RELATIVISTIC THOMAS–FERMI MODEL OF COMPRESSED ATOM. Howse, James Lebert Jr. Lexington, Ky.; Univ. of Kentucky (1967). 110.

Thesis.

A method is proposed by which the ordinary Thomas–Fermi theory of the compressed atom may be extended to include relativistic effects. The principal difficulty in effecting this extension arises from the fact that the relativistic analog of the ordinary Thomas–Fermi differential equation exhibits a singularity at the origin. This singularity is of such a nature that the integral of the resulting charge density over the volume of the atom is infinite. This difficulty is circumvented by the application of a set of boundary conditions that implies the existence of a small hole in the electron cloud. The existence and uniqueness of the solutions to the relativistic differential equation subject to these boundary conditions were established and the continuity properties of the solutions with respect to various parameters of the system were examined. A method was developed by which the variation of the pressure at the outer surface of the atom could be determined as a function of the variation of the radius and charge content of the hole. The application of this method showed the pressure to be quite insensitive to variations in the radius of the hole and in the amount of electronic charge contained in it. An approximate expression for the solution of the relativistic differential equation was derived for very high compression and an approximation for the pressure was determined to the same accuracy. The range of validity of this approximation was estimated in order to delineate the region in which numerical integration of the differential equation would be appropriate. Once the approximate range of validity of the high-compression approximation was established, the differential equation was integrated numerically for values of the atomic number equal to 5, 25, 50, 75, and 92. This integration was performed in such a manner that the resulting values of the radius of the atom would cover the values between the region of validity of the high-compression approximation and the region on which the difference between the relativistic and nonrelativistic results was small. The values of the pressure and density corresponding to each solution were calculated and the results were tabulated along with the associated value of the solution at the atomic radius. The high-compression approximation was used as a guide in modifying a nonrelativistic approximation of March in such a manner as to obtain a relativistic approximation valid for any value of the atomic radius. The results of this modified approximation were compared with the corresponding quantities obtained from the numerical integration and an estimate of the error was made. Finally, the results of the relativistic calculations are compared to those obtained from the nonrelativistic method in order to delineate the region in which the two methods yield significantly different results. (Diss. Abstr. Int., B)

**17701** QUASIPARTICLES IN ATOMIC SHELL THEORY. Armstrong, Lloyd Jr.; Judd, B. R. (Johns Hopkins Univ., Baltimore). Proc. Roy. Soc. (London), Ser. A; 315: 27-37(3 Feb 1970).

A new scheme is described for defining and classifying the states of the electronic configurations $l^N$. The spaces for which the spin orientation is either up or down are both factored into two parts. Each of these parts (distinguished by a symbol $\theta$) corresponds to the irreducible representation $(\frac{1}{2}\frac{1}{2}\ldots\frac{1}{2})$ of the rotation group $R_\theta(2l+1)$. The generators for this group are constructed from quasi-particle creation and annihilation operators. The angular momentum quantum numbers $l_\theta$ arising from the decomposition of $(\frac{1}{2}\frac{1}{2}\ldots\frac{1}{2})$ into representations of $R_\theta(3)$ can be used to couple the four parts together. No ambiguities arise when $l < 9$, thereby giving a very satisfactory coupling scheme. No coefficients of fractional parentage (c.f.p.) are required in the calculation of matrix elements. Simple explanations are given for some null c.f.p. and for some repeated eigenvalues of an operator that had previously been used to classify the states of $g^N$. (auth) (UK)

**17702** ATOMIC STRUCTURE CALCULATIONS IN A FACTORIZED SHELL. Armstrong, Lloyd Jr.; Judd, B. R. (Johns Hopkins Univ., Baltimore). Proc. Roy. Soc. (London), Ser. A; 315: 39-48(3 Feb 1970).

A method is described for calculating matrix elements of operators in a basis in which the spin-up and spin-down spaces of an atomic l shell are both split into separate parts. Instead of elaborate tables of fractional parentage coefficients, only a few reduced matrix elements are required. These are tabulated for d, f, g, and h electrons. The transformation coefficients relating the states in the new basis to the familiar LS states are given for f electrons. An operator $e_h$ that separates and classifies repeating terms of the configuration $h^N$ (in analogy to the separation achieved by Racah for $f^N$) is shown to take a simpler form if parts off-diagonal with respect to N are added to it, thereby accounting for some puzzling coincidences in the eigenvalues of $e_h$. (auth) (UK)

**17703** EXTENSIONS OF THE ADIABATIC THEOREM IN QUANTUM MECHANICS. Young, Ralph H.; Deal, Walter J. Jr. (Stanford Univ., Calif.). Phys. Rev., A; 1: 419-29(Feb 1970).

In a quantum-mechanical problem with a slowly varying Hamiltonian, such as appears in a semiclassical treatment of inelastic atomic collisions, it is common to restrict attention to a small number of states among which transitions are anticipated. This procedure is justified by an extension of the conventional adiabatic theorem to nearly degenerate states. The correct mixing within the restricted basis is determined by a time-dependent variational principle. The contribution of states outside the basis vanishes as the time scale for variation of the Hamiltonian becomes large. A further generalization deals with pseudoeigenfunctions, such as appear in the theory of the Stark effect. (auth)

**17704** EFFECTIVE-FIELD CALCULATION OF ELECTRONIC POLARIZABILITY. Litt, Clotilde (Univ., Liege). Phys. Rev., A; 1: 258-60(Feb 1970).

Electronic multipolar polarizabilities of closed-shell isolated atomic systems are calculated by a variational method using, as trial functions, the perturbed wave functions given by the uncoupled Hartree–Fock method. The external field is replaced by an effective parametric field taking into account the coupling between the deformations of the various orbitals. Numerical results obtained for $F^-$ and $Cl^-$ show a much better agreement with the experimental data. (auth)

## Cosmic Radiation

*Refer also to abstracts 17456, 17541, 17555, 17581, 17616, 17809, 17848, 18058, and 18064.*

**17705** ORIGIN OF COSMIC RAYS. I. INTRODUCTION. METAGALACTIC MODELS. Ginzburg, V. L. Comments Astrophys. Space Phys.; 2: 1-5(Jan-Feb 1970).

To solve the problem of the origin of cosmic rays near the Earth, it is necessary first of all to determine where cosmic rays originate i.e., what volume do they occupy. Four alternatives (models) most relevant at the present time are mentioned: the universal (or uniform) metagalactic model, local metagalactic models, galactic model with halo, and galactic model of disc type. It is concluded that the metagalactic models are improbable. (M.H.R.)

**17706** SOME PROBLEMS OF INVESTIGATING PERIODICITIES OF COSMIC-RAY TIME SERIES. Kota, J.; Somogyi, A. (Central Research Inst. of Physics, Budapest). Acta Phys. Acad. Sci. Hung.; 27: 523-48(1969).

A generalization of the method of the analysis of variance is given to investigate the existence and the shape of a periodicity with given length of period. Allowance is made for slow variations of the intensity of cosmic rays as well as for meteorological effects. In addition to the exact test of the existence of the periodicity, maximum likelihood estimates both of the constants characterizing the shape of the periodicity and of the mean square amplitude of the periodic function are given, together with their respective statistical errors, in the case of an arbitrary number of meteorological factors affecting the intensity of the cosmic radiation. Disadvantages in applying the Fourier method when investigating a periodicity with given length of period are pointed out as well as the fact that the determination of meteorological coefficients, if done statistically, must not be separated from the analysis of the periodicity. (auth)

**17707** OBSERVATION OF STRUCTURE IN CHERENKOV PULSES FROM EXTENSIVE AIR SHOWERS USING FAST TECHNIQUES. Bosia, G.; Castagnoli, C.; Dardo, M.; Marangoni, G. (Univ., Turin). Nature (London); 225: 532-3(7 Feb 1970).

It is stated that in an experiment on the structure of Cherenkov light flashes from the night sky carried out at the Testa Grigia Laboratory three anomalous Cherenkov pulses were observed. In two cases (A and B) the pulse was double, and there were two light flashes with a short relative delay. Event A is reproduced photographically. In case C the observed light flash was slower and longer than usual. The equipment and technique employed are described in detail. The authors observed 455 extensive air shower Cherenkov flashes in a run of 70 hours on moonless clear nights, and the characteristics of the three anomalous pulses are shown tabulated, together with those of normal pulses. Physical or instrumental explanations for the anomalous pulses are discussed. A possible interpretation (apart from extreme fluctuations in a normal shower) may be derived from successive interactions of a primary nucleus in the atmosphere, and a simple Monte Carlo calculation shows the possibility of obtaining the observed delays if the energy of the nucleus is $10^{12}$ eV. The presence of a very massive particle, generated in the first N–N collision, could also possibly explain the effect. A simple model shows that such a particle could produce a detectable shower with the measured delay ob-

served in events A and B if the particle mass is ~10 GeV $c^{-2}$. It is considered that the work opens up a new approach to the study of air showers. (UK)

17708 ON THE BEHAVIOR OF SHORT-LIVED COSMIC RAY PRODUCED NUCLIDES IN THE LOWER ATMOSPHERE. Roedel, Walter (Univ., Heidelberg). Z. Naturforsch.; 24a: 1897-1903(Dec 1969).

Some aspects of short-lived cosmic ray produced nuclides in the lower atmosphere, especially of $^{24}$Na, and their qualities as tracers for atmospheric motion are studied. The $^{24}$Na production rate has been estimated. The distribution of this nuclide as a function of altitude in the lower atmosphere has been described by a steady state eddy diffusion model. Measurements of $^{24}$Na in ground-level air have been carried out. The measured activities varied from $0.07 \times 10^{-3}$ to $0.28 \times 10^{-3}$ dpm/m$^3$. These figures are in good accordance with the calculated values for reasonable diffusion parameters. Calculations suggest that CRP-nuclides with lifetimes in the order of a day are useful as tracers for atmospheric motions in the range of eddy diffusion coefficients of about $5 \times 10^4$ to several $10^6$ cm$^2$ sec$^{-1}$, and for altitudes below four of five kilometers. Furthermore some relations between the specific radioactivity of rainwater and the specific activity of cloud-level air, with special respect to short-living CRP-nuclides are found. The evaluation of some measurements of $^{24}$Na activity in rain water shows good consistency between real atmospheric conditions and calculated values. (auth)

17709 STUDY OF THE LONG-TERM MODULATION OF GALACTIC COSMIC-RAY INTENSITY. Pathak, P. N.; Sarabhai, Vikram (Physical Research Lab., Ahmedabad, India). Planet. Space Sci.; 18: 81-94(Jan 1970).

It is shown that the 11-yr variation of the galactic cosmic-ray intensity is linearly related to the λ5303 coronal intensity close to the solar equator (±5° or ±10°). The available data on the temperature of the inner corona are used to calculate the annual average solar wind velocity at low heliolatitudes (±5°) for each year during the period 1957–1967. The 11-yr variation of the computed velocity from the solar data is linearly related to the variation of cosmic-ray intensity. In terms of the theory of diffusion-convection, the empirical results are used to estimate the cosmic-ray intensity in the nearby interstellar space and hence the residual modulation at solar minimum. The following are the important conclusions: (1) The size of the modulating region (R) varies with solar cycle such that for a given rigidity P, $R - r/K$ = const. where r = 1 au and K is the isotropic diffusion coefficient. (2) The residual modulation of the cosmic-ray intensity is roughly proportional to $P^{-1}$. (3) The modulating parameter $\eta$ for 1965 is found to be slightly higher than the upper limit of 1 GV set by Gloeckler and Jokippi (1967). (auth) (UK)

17710 COMPTON-GETTING EFFECT FOR COSMIC-RAY PARTICLES AND PHOTONS AND THE LORENTZ INVARIANCE OF DISTRIBUTION FUNCTIONS. Forman, Miriam A. (State Univ. of New York, Stony Brook). Planet. Space Sci.; 18: 25-31 (Jan 1970).

The anisotropy introduced by the motion of an observer with velocity V through a particle or photon flux is derived from the Lorentz-invariance of distribution functions in phase space. The invariance of the black-body distribution function leads to a $\alpha = 1 + (V/c) \cos\theta$ dependence of the temperature of the 3°K thermal background radiation. For massive particles whose speed, v, is much greater than V, the Compton–Getting anisotropy $-(d(\ln f)/d(\ln p))\, V/v$ is added to the angular part of the distribution function, and the isotropic part is unchanged, to order V/v. The cosmic-ray proton spectrum at solar minimum is observed to have a region where the Compton–Getting anisotropy is zero. The Lorentz-invariance of the volume element in phase space, and the consequent invariance of distribution functions, are demonstrated in the Appendix. (auth) (UK)

17711 THE SPATIAL DISTRIBUTION OF COSMIC-RADIATION NEUTRONS NEAR THE ATMOSPHERE-EARTH INTERFACE. Gorshkov, G. V.; Tsvetkov, O. S. At. Energ. (USSR); 27: 352-3(Oct 1969). (In Russian).

The distribution of cosmic-radiation neutrons in the lower layers of the atmosphere up to 2000 m above sea level and below the interface in the atmosphere-Earth sandy media to a depth of 140 g. cm$^{-2}$ was determined. The distortion of the energy spectrum was derived from the cadmium ratio; $BF_3$ type proportional counters were used as neutron indicators. The semiconductor electron recording device consisted of 2 channels connected by an anticoincidence circuit to an interference-preventing third channel. The results indicated that above the surface of the Earth, to x > 60 g. cm$^{-2}$, the neutron intensity changes exponentially with the mean free neutron absorption path L = 150 ± 10 g. cm$^{-2}$. Below 500 m, the surface of the Earth interferes with the regular distribution. The lowest density of slow neutrons was noted at X ≈ 20 g. cm$^{-2}$ after which the curve rises sharply. On the other hand, the fast neutron intensity decreases as the surface of the Earth is approached. The increased slow-neutron density is due to the reflection of atmospheric neutrons, diffusion of slowed-down fast atmospheric neutrons in the ground, and diffusion of neutrons formed into the surface layer. The cadmium ratio of ~2.5 increases near the surface of the Earth to 3.8:1 at 40 m and to ~10:1 at the air-sand interface; it reaches 12:1 and 17:1 in wet sand at X = 7 and 45 g. cm$^{-2}$, respectively. (TTT)

17712 PROPERTIES OF EXTENSIVE AIR SHOWERS OF COSMIC RAYS AT THEIR MAXIMUM DEVELOPMENT. Capdevielle, Jean-Noeel; Dupuy, Jean; Cachon, Andre (Observatoire du Pic du Midi, Bagneres-de-Bigorre, France). Compt. Rend., Ser. B; 270: 294-7(26 Jan 1970). (In French).

With the help of a method of simulation of extensive air showers of cosmic rays, the existence of a linear relation between the energy of the primary particles and the number of particles at maximum was checked. Beyond $10^{17}$ eV there could be an effect of the mean free path, or a change in nuclear interactions. The formation of proton–antiproton cascades is considered. (France)

17713 THE HELIOCENTRIC LONGITUDE INTENSITY PROFILE OF 15-MeV PROTONS FROM THE FEBRUARY 5, 1965 SOLAR FLARE. O'Gallagher, J. J. (Univ. of Chicago). J. Geophys. Res.; 75: 1163-71(1 Mar 1970).

Simultaneous observations of 15-MeV protons from the solar flare of February 5, 1965, on Mariner 4 and IMP 2 show that the particle intensity decays faster near earth than at Mariner. It is shown that, if the longitudinal intensity profile for energetic flare particles is represented by a Gaussian in heliocentric longitude, then corotation of such a distribution past the two separated points of observation will account for this behavior. Furthermore, these observations provide a measure of the longitudinal scale of the distribution. In particular it is shown that the ratio of intensity at IMP 2 to that at Mariner 4 will be described by $R_{IM}(t) = R_0 \exp(-t/\tau_R)$ where $\tau_R$ is related directly both to $\Psi$, the half-width at 1/e times maximum of the assumed Gaussian distribution, and to the longitudinal separation of the two points of observation. The observations are well described by such an exponential relationship for the first 32 hours after the flare and yield for the half-width $\Psi = 15.3 \pm 1.0°$ throughout this period. The quoted limits on $\Psi$ correspond to a limit on $\kappa_\perp$, the diffusion coefficient perpendicular to the average spiral field, of $\kappa_\perp \lesssim 1.2 \times 10^{19}$ cm$^2$/sec. On the other hand, the magnitude of $\Psi$ early in the flare requires a diffusion coefficient of $\kappa_\perp \simeq 1.4 \times 10^{20}$ cm$^2$/sec if this initial width is to be explained by invoking only anisotropic diffusion from the immediate locality of the flare on the sun. The implications of this discrepancy are discussed with respect to the predictions of anisotropic diffusion and the random walk of magnetic field lines. (auth)

17714 LATITUDE DEPENDENCE OF CHARGED-PARTICLE ALBEDO ESTIMATED FROM BALLOON-BORNE GEIGER TELESCOPES. Koenig, P. J.; Maree, J. P.; Stoker, P. H.; van der Walt, A. J. (Potchefstroom Univ., S. Afr.). J. Geophys. Res.; 75: 1172-7(1 Mar 1970).

From the atmospheric depth-intensity distributions for a series of balloon flights with standard Geiger telescopes during the IQSY, the total charged particle intensity at the top of the atmosphere was obtained. The resulting charged albedo intensity, as function of cutoff rigidity, compares well with the estimates Webber (1967) obtained from balloon-borne Cherenkov counter and satellite observations for recorders of 0.5 g cm$^{-2}$. At high latitudes the percentage of albedo intensity corresponds to Webber's splash albedo intensity, rising to the total (splash + re-entrant) albedo intensity from about 55° to 40° invariant latitude. (auth)

17715 THE VARIATION WITH A PERIOD OF TWO SOLAR CYCLES IN THE COSMIC-RAY DIURNAL ANISOTROPY FOR THE NUCLEONIC COMPONENT. Duggal, S. P.; Forbush, S. E.; Pomerantz, M. A. (Franklin Inst., Swarthmore, Pa.). J. Geophys. Res.; 75: 1150-6(1 Mar 1970).

It has been shown previously that annual means of the diurnal anisotropy determined from 30 years of ionization chamber data result from the superposition of two distinct independent components. One component, W, has its maximum (or minimum) in the asymptotic direction 128° east of the sun-earth line, with amplitude that varies sinusoidally with a period of two solar cycles. The other, V, has its maximum in the asymptotic direction 90° east of the sun-earth line; it is well correlated with magnetic activity and varies with the sunspot cycle. For the observed component of the total diurnal anisotropy 90° east of the sun (which contains all of V and 79% of W), a correlation coefficient of 0.94

was found between annual means from the Huancayo neutron monitor and from ionization chambers. The resulting implication that V and W were each about 1.35 times greater in the neutron monitor data is explicitly established. Analysis of the diurnal anisotropy, from a geographical distribution of neutron monitors normalized to Churchill, shows that there V and W are each about twice the value for ionization chambers. These results reveal that the variational spectrum is the same for V and for W within the experimental uncertainties. Thus, it is valid to derive variational spectra from total vectors. (auth)

17716 VARIATIONS OF INTENSITY OF COSMIC RAYS WITH PERIODS BETWEEN 20 AND 28 HOURS. Binder, O. H. (Univ., Kiel). Z. Geophys.; 35: 565-78(Dec 1969). (In German).

Intensity variations of cosmic ray neutrons and mesons have been analyzed with the aim to isolate a lunar day period. Previous evaluations have been extended to 6.5 years and the significance of other periods around a solar day has been tested. It turned out that for periods between 22 and 26 hours the lunar day period is not outstanding and the apparent amplitude must be attributed to the solar daily variation. (auth)

17717 LOW-ENERGY COSMIC-RAY POSITRONS AND 0.51-MeV GAMMA RAYS FROM THE GALAXY. Ramaty, R.; Stecker, F. W.; Misra, D. (Goddard Space Flight Center, Greenbelt, Md.). J. Geophys. Res.; 75: 1141-9(1 Mar 1970).

Large fluxes of low-energy cosmic rays in interstellar space may produce, via unstable CNO beta emitters, large fluxes of low-energy positrons and a detectable intensity of 0.51-MeV $\gamma$ rays. Although on a galactic scale these cosmic-ray intensities are probably untenable because they conflict with the dynamics of the interstellar medium, they may exist on a smaller scale of the order of the stopping distances of both low-energy cosmic rays and positrons. The results of a detailed calculation are compared with direct positron measurements at the earth, and the observability of the annihilation radiation above the isotropic x-ray background is discussed. (auth)

17718 MODELING OF SOLAR COSMIC-RAY EVENTS BASED ON RECENT OBSERVATIONS. Baker, M. B.; Santina, R. E.; Masley, A. J. (McDonnell Douglas Astronautics Co., Santa Monica, Calif.). AIAA (Amer. Inst. Aeronaut. Astronaut.) J.; 7: 2105-10(Nov 1969).

In order to assess the magnitude of a solar cosmic-ray event after the first particles have been detected, solar cosmic-ray event models were developed that relate a spectral parameter to a dose parameter. Spectrometer data obtained early in an event would be used to make projections of the total expected event dose and other dose parameters. Two models were considered. The first model, Epeak, relates the energy of the particles reaching maximum intensity to the percent dose remaining. It was found that the plots of energy (of protons reaching maximum intensity) vs percent dose accumulated correlated well for several of the events. The second model is based on theoretical treatments of solar cosmic-ray propagation assuming isotropic diffusion. With this model the time-integrated intensity is calculated from data early in the event. The dose rate and total dose are then calculated. For most of the events analyzed, this technique gives reasonable dose projections quite early in the event. (auth)

## Direct Energy Conversion

17719 (INR-1095) ELECTRICAL PARAMETERS IN THE FARADAY-TYPE MHD GENERATOR WITH NONUNIFORM GAS PROPERTIES IN THE MAGNETIC FIELD DIRECTION. Celinski, Z. (Institute of Nuclear Research, Warsaw (Poland)). 1969. 76p. Dep. CFSTI (U. S. Sales Only).

The effects of gas velocity and temperature distributions in the direction of a magnetic field, on the electrical parameters of the Faraday-type MHD generator are considered. As gas properties are varying along the z axis, circulating currents are flowing in the cross-sectional area of the channel due to the nonuniform distribution of the gas velocity. These currents induce the Hall circulating currents along the x axis. The Ohmic losses due to the circulating currents are independent of the load factor. They are not high, e.g., they are less than 3% of the generated power for the typical distributions. The maximum point of the efficiency curve versus load factor is shifted to the lower values of the generator loading. The terminal voltage and generated power slightly increase; the internal resistance does not change in a sufficient manner in comparison to the constant gas property generator. The weak Hall fields can be induced in the open circuit conditions of the generator due to the nonuniform distribution of the Hall parameter. A constant channel cross section, no-leakage currents in the walls, a constant magnetic field, as well as constant electrical and gasdynamical parameters along the channel, are assumed. It is also assumed that the distributions of the gas parameters are independent of the load factor. A numerical example is calculated. (auth)

17720 (INR-1096) ELECTRICAL PARAMETERS IN THE FARADAY-TYPE MHD GENERATOR WITH NONUNIFORM GAS PROPERTIES IN THE ELECTRIC FIELD DIRECTION. Celinski, Z. (Institute of Nuclear Research, Warsaw (Poland)). 1969. 69p. Dep. CFSTI (U. S. Sales Only).

The effects of gas velocity and temperature distributions in the direction of an induced electrical field, on the electrical parameters of the Faraday-type MHD generator are considered. As gas properties are varying in the y direction, strong Hall currents are flowing in the x direction. These currents deteriorate the electrical performance of the generator; the A parameter which characterizes this deterioration is determined. The decrease of electrical terminal values may be strong especially is the case when the magnetic induction is high. The parameter A is proportional to $B^2$ and depends on the distribution functions of the gas conductivity and of the Hall parameter. The distributions of the electrical parameters in the y direction (current density, electrical potential, electrical field) become more nonuniform with the increasing of B. A constant channel cross section, no-leakage currents in the walls, a constant magnetic field, as well as constant electrical and gasdynamical parameters along the channel are assumed. It is also assumed that the distributions of the gas parameters are independent of the load factor. A numerical example is calculated. (auth)

17721 (NP-18143) COMPARISON OF EXPERIMENTAL AND ANALYTICAL RESULTS FOR A 20 MW COMBUSTION-DRIVEN HALL CONFIGURATION MHD GENERATOR. Research Report 344. Sonju, O. K.; Teno, J.; Brogan, T. R. (Avco Research Lab., Everett, Mass.). Nov 1969. 22p.

The results of a continuing effort to upgrade "design" and "off-design" analytical techniques for MHD generators are reported. The analytical techniques are applicable to all types of generators, but the work reported here is primarily concerned with the analysis of Hall MHD generators. The analytical techniques used in the analysis, including boundary layer analysis, gas nonuniformity considerations, and electrode drop effects, are reviewed. As a check on the analysis, comparisons between predicted and observed operating parameters of a 20-MW Hall generator are made. Although some small discrepancies still exist, the correlation between predicted and observed performance is very good. The analysis is shown to predict the maximum loading (stalling point) of Hall generators accurately. Based on the conclusion that the analysis is quite accurate in view of the comparisons and checks made, it is felt that these analytical techniques can be used with some confidence to design and predict the performance of future MHD generators with a high degree of accuracy. (auth)

17722 (TUBIK-15) COMPARATIVE PERFORMANCE ANALYSIS OF LINEAR MPD GENERATORS. Bartsch, Gerhard (Technische Universitaet, Berlin (West Germany). Institut fuer Kerntechnik). Sep 1969. 181p. (In German). Dep. CFSTI (U. S. Sales Only).

Different types of linear MPD generators are compared, considering power, efficiency, and load factors. Besides special operating conditions (i.e., maximum power or maximum efficiency operation) Hall effect, ion slip, and segmentation ratio are taken into account. These conditions are given separately and explicitly in calculations and diagrams. Thus, their influence on value and slope of parameters such as power and efficiency are distinct. (auth)

17723 VOLTAGE DISTRIBUTION IN CHANNELS OF FARADAY-TYPE MHD GENERATORS WITH SEGMENTED ELECTRODES. Ogiwara, Hiroyasu (Tokyo Shibaura Electric Co., Kawasaki, Japan). Denki Gakkai Zasshi; 89-9: 1719-26 (Sep 1969). (In Japanese).

The effects of the insulation between electrodes and of the resistance of the boundary layer on the voltage distribution in the Faraday-type MHD generators are discussed, making use of the experiments performed at Toshiba Central Research Laboratory and elsewhere. The output voltage-current relation of an equivalent circuit was calculated, in which the resistance of boundary layer $R_b$, and the leakage resistance along wall $R_w$ were taken into account. The performance of an actual generator relative to the ideal one was evaluated by introducing a function F and a factor K. Effect of $R_b$ and $R_w$ on F and K is illustrated. The generating characteristic is also given. The actual voltage distribution measured at Toshiba, the experimental results of Armstrong

et al. and Reseck et al. were also analyzed by this method and compared. Two electrode phenomena influencing voltage distribution were discussed. (NSA of Japan)

**17724** CONTROLLING CESIUM RESERVOIR TEMPERATURE FOR THERMIONIC CONVERTERS. Untermyer II, Samuel (to United States Atomic Energy Commission). U. S. Patent 3,493,792. 3 Feb 1970.

This patent relates to a thermionic converter composed of a thermionic unit or diode with cesium vapor and containing a cesium reservoir, wherein the cesium reservoir temperature is controlled by applying a voltage to the reservoir, causing electric current to flow to or from the reservoir, thereby providing electron heating or cooling of the cesium, thus controlling the cesium pressure within the unit or diode to obtain maximum thermionic output. (AEC)

**17725** TECHNICO-ECONOMIC INDICES FOR SUPERCONDUCTIVE MAGNETIC SYSTEM FOR MHD GENERATORS. Rossievskii, G. I.; Goncharova, V. S.; Kir'enin, I. A. (Moscow Inst. of Engineering and Economics). Teplofiz. Vys. Temp.; 7: 1192-7(Nov-Dec 1969). (In Russian).

Data are given on technological and economic optimization of superconducting magnetic systems for MHD generators. An approximation method is given for calculating the weight and cost of windings for a magnetic system. (tr-auth)

**17726** ROLE OF HIGHER HARMONICS IN MHD MACHINES WITH FINITE WIDTH CHANNELS. Kalnin, T. K. Magn. Gidrodin., Akad. Nauk Lat. SSR; No. 3, 147-9(Jul-Sep 1969). (In Russian).

It is shown that the higher-space harmonics, including cusped harmonics, must be considered in calculations of electromagnetic pumps with finite-width channels. (R.V.J.)

**17727** OPTIMIZATION OF FARADAY GENERATORS WITH NONEQUILIBRIUM IONIZATION. Zampaglione, V. (CNEN, Rome). AIAA (Amer. Inst. Aeronaut. Astronaut.) J.; 7: 1619-22(Aug 1969).

Some of the optimization problems of Faraday MHD generators are considered: determining the variation of cross-sectional area, loading factor, and magnetic field strength to obtain a given power output from the minimum-sized duct with a given pressure drop at the ends. Nonequilibrium ionization and plasma turbulence are taken into account by assuming local Saha equilibrium at the electron's elevated temperature. The problem of maximizing the generator efficiency for a fixed duct length is considered. (D.L.C.)

## Fluid Physics

*Refer also to abstracts 17726, 17893, 17933, and 18743.*

**17728** THE HALL EFFECT ON THE MAGNETOGASDYNAMIC FLOW PAST AN AXISYMMETRIC BODY. II. BOUNDARY LAYER FLOW. Naruse, Humio; Nishijima, Shoichi (Tokyo Univ.). J. Phys. Soc. Jap.; 28: 758-66(Mar 1970).

In order to see the torque acting on an axisymmetric body as the result of the Hall effect on the magnetogasdynamic flow, the boundary layer of the steady, incompressible, magnetogasdynamic flow past an axisymmetric insulator is studied on the assumption that a magnetic field is parallel to the velocity at infinity upstream and the magnetic Reynolds number $R_m$ is small. The equations governing the flow in the above boundary layer are reduced. Further, the equation for the velocity component in the azimuthal direction is derived by expanding these in power series with respect to $\alpha^2 R_m$, where $\alpha^2$ is the pressure number. For the cases of a sphere and a circular disc this equation is solved, being expanded in power series of X where X is the distance from the forward stagnation point measured along the surface, and the torque exerted on the body is determined. (auth)

**17729** CERTAIN YAWED MAGNETOGASDYNAMIC FLOWS. Power, G.; Walker, D. (Univ. of Nottingham, Eng.). Appl. Sci. Res. (The Hague); 21: 341-55(Dec 1969).

Certain steady yawed magnetogasdynamic flows, in which the magnetic field is everywhere parallel to the velocity field, are related to certain reduced three-dimensional compressible gas flows having zero magnetic field. Under a restriction, the reduced flows are linked, by certain reciprocal relations, to a four-parameter class of plane gas flows. In the instance of constant entropy an approximation method is suggested for obtaining magnetogasdynamic flows from the corresponding plane, irrotational gasdynamic flows and examples are given. (auth)

**17730** HALL EFFECT ON THE MAGNETOGASDYNAMIC FLOW PAST AN AXI-SYMMETRIC BODY. I. INVISCID FLOW. Naruse, Humio (Tokyo Univ.). J. Phys. Soc. Jap.; 28: 238-48 (Jan 1970).

In order to see the qualitative properties of the Hall effect on the magnetogasdynamic flow past an axisymmetric body at small magnetic Reynolds number $R_m$ and large Reynolds number $R_e$, the steady, incompressible, inviscid flow past a body of revolution at zero incidence is studied on the assumption that a magnetic field is parallel to the velocity at infinity upstream and the body is an insulator. The equations governing the azimuthal components of the velocity and magnetic field are derived, being expanded in power series with respect to $\alpha^2 R_m$, where $\alpha^2$ is the pressure number. A general method to solve these equations is discussed for the axisymmetric obstacle of arbitrary shape at zero incidence, and the surface velocity, the magnetic field in the azimuthal direction and the electric field are determined for a sphere and a circular disc. (auth)

**17731** HEAT TRANSFER TO MHD SLIP FLOW IN THE THERMAL ENTRANCE REGION OF A PARALLEL PLATE CHANNEL. Kikuchi, Kentaro (Government Mechanical Lab., Tokyo). Kikai Shikenjo Shoho; 23: No. 3, 109-13(May 1969). (In Japanese).

Heat transfer to an MHD fluid for the case of uniform heat flux at the wall in the thermal entrance region of a flat plate channel is investigated. In the thermal entrance region, the velocity profile is assumed to be constant, and a finite difference method developed by Hwang, Knieper, and Fan is introduced in this investigation. (NSA of Japan) (TSS)

**17732** STEADY PLANE MAGNETOHYDRODYNAMIC FLOW. Gundersen, Roy M. (Univ. of Wisconsin, Madison). J. Math. Mech.; 19: 357-70(Oct 1969).

Martin's second method (1950), which showed that the determination of the plane steady flow of a fluid could be reduced to finding two functions, the Bernoulli function and the direction function, which together satisfy a quasi-linear partial differential equation is extended to a special class of MHD flows. It is possible to extend the idea of simple waves in rotational, isoenergetic flows to the magnetic case. As a by-product, it is found that the images of the characteristics in the hodograph plane form a fixed net of curves, and do not depend on the solution under consideration, provided that the flow is irrotational. The analysis is based upon, and follows quite closely, the methods developed by Martin (1950, 1951) and Hansen and Martin (1951); generally speaking, the solutions reduce exactly to the pertinent solutions in the cited references when the limit of vanishing magnetic field is taken. Naylor (1954) used the Legendre contact transformation to develop a theory of simple waves in rotational gas flow, based on the concept of one-parameter velocity fields. In only one of the magnetic cases considered (the transverse field case) is it possible to extend Naylor's study to magnetic flows. (IAA)

**17733** THE SOLUTIONS TO A CLASS OF MAGNETOHYDRODYNAMIC FLOWS WITH ORTHOGONAL MAGNETIC AND VELOCITY FIELD DISTRIBUTIONS. Kingston, John G.; Talbot, Richard F. (Univ. of Nottingham, Eng.). Z. Angew. Math. Phys.; 20: 956-65(25 Nov 1969).

Complete solutions are established for two-dimensional, steady, magnetohydrodynamic flows of an inviscid, thermally nonconducting incompressible fluid having infinite electrical conductivity, when the magnetic and velocity fields are everywhere orthogonal. The plane incompressible problem is thoroughly investigated, and it is found that there are a limited number of possible flow configurations. It is already known that solutions exist for parallel straight line flow, circular (concentric) flow, and radial flow, and now it is shown that the only other solutions are certain types of spiral flows. (M.H.R.)

**17734** ON THE UNSTEADY HYDROMAGNETIC FREE CONVECTION FLOW PAST A VERTICAL INFINITE FLAT PLATE. Pop, Ioan (Univ., Cluj). Indian J. Phys.; 43: 196-200(Apr 1969).

The unsteady laminar free-convection flow of viscous incompressible and conducting fluid past a vertical infinite flat plate whose temperature varies as some powers of time in the presence of a constant horizontal magnetic field is considered. (auth)

**17735** STABILITY OF PLANE SHOCK WAVE FRONT AT SMALL MAGNETIC REYNOLDS NUMBERS. Sinkevich, O. A. (Inst. of High Temperatures, Moscow). Teplofiz. Vys. Temp.; 7: 1126-33(Nov-Dec 1969). (In Russian).

Stability of plane shock waves moving in external magnetic fields was investigated assuming that the magnetic Reynolds number, calculated according to the electric conductivity coefficient, was less than unity. It is shown that the stability is determined by electric conductivity factors as a function of temperature. (tr-auth)

**17736** ANALYSIS OF VELOCITY PROFILE AND HYDRAULIC RESISTANCE DURING A TURBULENT FLOW IN A TUBE IN A LONGITUDINAL MAGNETIC FIELD. Duganov, V. V.; Kovner, D. S. (Moscow Aviation Inst.). Teplofiz. Vys. Temp.; 7: 1227-30(Nov-Dec 1969). (In Russian).

Experiments and the theory of dimensionality were used by V. G. Zhilin (Teplofiz. Vys. Temp., 6: No. 4, (1968)) to show that the function describing the velocity profile is expressed by $u/u_* = f_2(\eta) + f_4(\eta)$ $(Ha/Re_* - 0.13)$. An attempt is made here to show that, in a general case, with $Re_m \ll 1$, $\varphi = \varphi(Re_*, Ha, \xi)$ for the whole tube, then for points close to the wall the velocity profile should not depend on the radius, i.e., that $\varphi = X(Re_*\xi, Ha\xi)$. Results of the calculation are given in graphical form. (R.V.J.)

**17737** POTENTIAL DISTRIBUTION IN AN MHD CHANNEL WITH THIN CONDUCTING WALLS. Vasil'ev, V. F.; Lavrent'ev, I. V. Magn. Gidrodin., Akad. Nauk Lat. SSR; No. 3, 142-3(Jul-Sep 1969). (In Russian).

A correction is given for Shercliff's solution of the problem of the potential distribution in a plane MHD channel with thin conducting walls. The error was found related to the expansion of the solution into a nonorthogonal function series. (R.V.J.)

**17738** ELECTRICAL MODELING OF THE TEMPERATURE FIELD OF MHD DEVICES WITH HEAT NONLINEARITIES TAKEN INTO ACCOUNT. Ratniek, U. A.; Tabaks, K. K. Magn. Gidrodin., Akad. Nauk Lat. SSR; No. 3, 149-51(Jul-Sep 1969). (In Russian).

A method was found for determining the continuous temperature field for MHD devices considering nonlinearity of the thermal properties of materials. The thermal conductivity was calculated in a plane linear induction pump along the longitudinal cross section of the inductor. (R.V.J.)

**17739** REVERSIBILITY OF AN IDEALLY CONDUCTING MHD CHANNEL REGIME. Zander, Yu. K. Magn. Gidrodin., Akad. Nauk Lat. SSR; No. 3, 151-3(Jul-Sep 1969). (In Russian).

It is shown that operation of the ideally conducting MHD channel depends, significantly, on the magnitude of the load coefficient k, and this factor must be considered in resolving the boundary problems of channels. (R.V.J.)

**17740** PERFORMANCE OF A 500-KJOULE MHD WIND TUNNEL. Grabowsky, W. R.; Durran, D. A.; Mirels, H. (Aerospace Corp., El Segundo, Calif.). AIAA (Amer. Inst. Aeronaut. Astronaut.) J.; 7: 184-52(Oct 1969).

The operation of a pulsed MHD accelerator is described for a MHD wind-tunnel application. The accelerator is designed to provide a 50% velocity increase (from 15.5 kft/sec to 24 kft/sec), at constant enthalpy, of a gas at approximately atmospheric pressure. The accelerator gas source is a hot shot that heats potassium-seeded nitrogen to 9000°K and 1400 atm. The gas is expanded into a segmented electrode (94 pair) MHD accelerator channel. After tunnel startup, a 3-msec constant power pulse is switched on the electrodes so that current flow is approximately perpendicular to a quasi-steady 4-wb/m$^2$ magnetic field. The power-on to power-off velocity ratio ($\equiv u_n/u_f$) at the accelerator exit is determined from changes in the stagnation pressure and open circuit induced potential. The corresponding enthalpy ratio ($\equiv h_n/h_f$) is determined from the static pressure change and $u_n/u_f$. Results 0.5 msec after switch-on indicate $u_n/u_f \approx 1.5$ ($u_n \approx 24$ kft/sec) and $h_n/h_f \approx 1.0$. As a result of constant volumetric power addition and a decaying mass flow, $u_n/u_f$ and $h_n/h_f$ increase to 1.7 and 1.2, respectively, just prior to channel power switch-off. Although these results are essentially the design values, the detailed performance of the accelerator appears to be significantly influenced by spatial nonuniformities in the flow. (auth)

**17741** CORRECT FORMULATION OF AIRFOIL PROBLEMS IN MAGNETOAERODYNAMICS. Dragos, L. (Faculty of Mathematics and Mechanics, Bucharest). AIAA (Amer. Inst. Aeronaut. Astronaut.) J.; 7: 2014-16(Oct 1969).

Previous solutions of thin airfoil problems are incorrect in that the kernels of their integral equations are expressed by divergent integrals. An attempt is made to revise the solution; only the case of crossed fields is considered. The dispersion relation, general solution, and boundary conditions are derived, and the convergence of the integrals is examined. (D.L.C.)

**17742** ARC MOTION IN HIGH-PRESSURE CROSS-FIELD DEVICES. Stewart, R. B.; Sabol, A. P. (Langley Research Center, Hampton, Va.). AIAA (Amer. Inst. Aeronaut. Astronaut.) J.; 7: 2024-6(Oct 1969).

Anomalous behavior was observed in the rotational speed of arcs in coaxial cross-field plasma devices with cathodes of logarithmic spiral displacement, as compared with other cross-field devices of different design. The cathode root velocities for the logarithmic-spiral device are much higher (as much as four times higher) than for the other devices. The probable cause of this effect is additional Lorentz forces from the outward radial displacement of the cathode sheath. It is shown that at low velocities, the gain in speed in the spiral geometry is three times greater than that with the circular geometry for only twice the input of energy. (D.L.C.)

**17743** UNSTEADY MHD FLOW IN ARBITRARY DUCTS BY POINT-MATCHING METHOD. Wu, S. T. (Univ. of Alabama, Huntsville); Jeng, D. R. AIAA (Amer. Inst. Aeronaut. Astronaut.) J.; 7: 1612-14(Aug 1969).

Unsteady, fully developed, laminar, incompressible flow of a conducting fluid with a uniform transverse magnetic field in ducts of arbitrary cross section, due to an arbitrary time-varying pressure gradient, is studied by the point-matching method. Only the case of small magnetic Reynolds number is considered, and the hydrodynamical response to a unit impulsive change in the pressure gradient is determined. Numerical results are presented for a square duct. (D.L.C.)

**17744** MAGNETO–HYPERSONIC BOUNDARY-LAYER INTERACTIONS. Sastry, M. S.; Chandran, S. (Space Science Tech. Centre, Trivandrum, India). AIAA (Amer. Inst. Aeronaut. Astronaut.) J.; 7: 2362-3(Dec 1969).

A theoretical analysis gives a complete flow picture of the magneto viscous boundary-layer interactions. Graphs showing the boundary-layer thickness and Hartmann and Reynolds numbers are given. (M.O.W.)

## Geophysics (Upper Atmosphere)

*Refer also to abstracts 16699, 16929, and 17556.*

**17745** (AD–696292) ELF PROPAGATION AND EMISSION IN THE MAGNETOSPHERE. Liemohn, H. B. (Boeing Scientific Research Labs., Seattle, Wash.). Aug 1969; Revised Oct 1969. 61p. (D–1–82–890). CFSTI.

Considerable research progress has been achieved on elf signals in the magnetosphere as a consequence of satellite and ground-based studies. Attention is focused on the frequency band from 0.2 to 500 Hz, which is well below the minimum electron plasma and cyclotron frequencies, so that the hydromagnetic approximation applies. Although the magneto-ionic medium is anisotropic and inhomogeneous, the propagation theory for the fast and Alfven modes in homogeneous media is adequate at these frequencies. The signal velocity of the fast mode is essentially isotropic for frequencies below the lower hybrid resonance. The Alfven mode is restricted to frequencies below the proton cyclotron frequency and its signal velocity is closely guided by the geomagnetic field. The morphology of these modes in remote regions of the magnetosphere is being developed from satellite studies. Statistics are available now on the elf noise distributions with latitude, local time, and geomagnetic activity. Studies on ground observations have concentrated on dispersion, polarization, and amplitude analyses. (auth) (USGRDR)

**17746** (JPRS–49889) PULSE OF THE EARTH'S MAGNETOSPHERE. Troitskaya, V. A. Translated from Priroda; No. 12, 9-17(1969). 18p. CFSTI.

A review type discussion is given on the magnetosphere and its properties. Micropulsations are discussed in particular. (M.O.W.)

**17747** (N–69–40039) ON THE METHOD OF DETERMINING THE MAGNETOSPHERIC ELECTRIC FIELD BY MEANS OF PARTICLE FLUX MEASUREMENTS. Note No. 224. Egidi, A.; Pizzella, G. (Rome Univ. (Italy). Istituto di Fisica). 10 Jun 1969. 12p. CFSTI.

A method is described for investigating the geoelectric field in the Earth's magnetosphere by measuring proton fluxes in various directions in the energy range 100 eV to 50 keV onboard a geostationary satellite. It is concluded that a particle experiment capable of determining fluxes with an accuracy of 1% would give valuable data. (STAR)

**17748** (N–69–41121) MEASUREMENTS OF PRECIPITATED 1 TO 20 keV PROTONS AND ELECTRONS DURING A BREAKUP AURORA. Bernstein, W.; Inouye, G. T.; Sanders, N. L.; Wax, R. L. (TRW Systems, Redondo Beach, Calif.). 27 Jan 1969. Contract NASw-1474. 29p. (NASA-CR–106476; TRW–6484-6008-RO). CFSTI.

Measurements of precipitating low energy (1 to 20 keV) protons and electrons during a breakup aurora are described. The observed proton fluxes were as high as $10^8$ cm$^{-2}$ sec$^{-1}$ keV$^{-1}$ str$^{-1}$ with an e-fold energy of ≈1 keV; the electron fluxes were ≈$10^8$ cm$^{-2}$ sec$^{-1}$ keV$^{-1}$ str$^{-1}$ with a spectral peak in the 2 to 4 keV region. During the flight, the rocket passed through the poleward boundary of the auroral form. One interpretation of the data sug-

gests that the proton and >2.5 keV electron precipitation boundaries coincided to within a distance of <1 km; the lower energy electron boundary extended several kilometers poleward of the proton boundary. Evidence for nonisotropic proton fluxes is presented. (auth) (STAR)

**17749** (UCRL-19309) LONG-TERM BEHAVIOR OF ENERGETIC INNER-BELT PROTONS. Heckman, Harry H.; Lindstrom, Peter J.; Nakano, George H. (California Univ., Berkeley. Lawrence Radiation Lab.). Oct 1969. Contract W-7405-eng-48. 27p. (CONF-690941-1). Dep. CFSTI.

From IAGA General Scientific Assembly, Madrid, Spain.

Experimental results are presented on the temporal behavior, since late 1962, of low-altitude trapped protons, $E \geq 57$ MeV. These data are interpreted in terms of the time-dependent continuity equation, using a source function that is empirically deduced from the data. The observed changes in the flux of 63-MeV protons between 1963 and mid-1969 are in agreement with those expected from solar-cycle changes in the atmosphere. Preliminary calculations that include semiannual as well as solar-cycle atmospheric density variations indicate that, beginning in 1967, semiannual changes in the 60-MeV proton flux should be observable at altitudes below about 350 km. The flux measurements are consistent with this computational result. (auth)

**17750** RADIO EMISSION ACCOMPANYING NUCLEAR EXPLOSIONS. Muranaga, Koji (Radio Res. Lab., Tokyo). Denpa Kenkyusho Kiho; 15: 324-32(May 1969). (In Japanese).

A mechanism of radioemission from a nuclear explosion is described by the theory of Gilinsky. According to the theory, prompt $\gamma$-ray emission from the explosion produces Compton electrons, which knock out secondary electrons. Some asymmetry in the resulting electric current is considered as the source of radioemission. First, the $\gamma$-ray emission function is assumed as $e^{-bt}$, with $b = 10^6$ sec$^{-1}$. Assuming a mean free path of the $\gamma$ photon of $3 \times 10^4$ cm, and neglecting multiple Compton scattering, conductivity of the ionized atmosphere was calculated. The radiation field from the Hertz dipole due to the asymmetric neutralization current is deduced and shown. Comparison with the solution given by Kompaneets shows that the Compton current was neglected by Kompaneets. Next, the rapid initial increase of $\gamma$-ray emission is taken into account for the calculation of a more realistic radiation field. Solutions given by Gilinsky are shown. (NSA of Japan)

**17751** MIDLATITUDE AURORA. Nakata, Yoshiaki (Radio Res. Lab., Tokyo). Denpa Kenkyusho Kio; 15: 249-52(May 1969). (In Japanese).

Observational data hitherto obtained of the midlatitude aurora, sometimes called Marcs, are summarized. The midlatitude aurora was discovered in 1957 in south France (latitude 43°) using a photoelectron tube at wavelength 6300 Å. Spectra other than at 6300 Å have never been detected by spectroscopic measurements; they are observed when the geomagnetic activity increases. The intensity increases with magnetic index $K_p$ or $A_p$. The mean height of Marcs is about 420 km. It is very stable in space, but is said to move slowly to the south at a speed ~5 to 50 m/sec in the northern hemisphere. In 1957, Marcs was visually observed five times in Japan. For four occasions, ionogram records were taken, in which discrete and diffuse echoes from Marcs could be recognized. Appearance of the echo at each of the three observatories in Japan was very different. Mechanism for excitation of the 6300-Å line is discussed. (NSA of Japan)

**17752** INTERACTION OF SOLAR PLASMA STREAM WITH GEOMAGNETIC FIELD. Kawashima, Nobuki (Japan Atomic Energy Res. Inst., Tokai, Japan). Denpa Kenkyusho Kiho; 15: 219-24(May 1969). (In Japanese).

Results of a model experiment for the interaction of the solar plasma stream with the geomagnetic field were compared with the observation by artificial satellites. Local time (dawn–dusk) asymmetry was found in the model experiments to the asymmetry of plasma sheet behind the earth. Westward current in the plasma behind the dipole was detected using a Rogowski coil. External southward magnetic field enhanced the plasma intrusion, while the northward field reduced it. This agrees with Dungey's model for the effect of the interplanetary field on plasma intrusion. The effect of the external magnetic field parallel to the plasma stream was also simulated. North–south asymmetry in the plasma intrusion was found. Time variation of the magnetic field behind the dipole was measured and compared with that in magnetic storm. Close resemblance was found. (NSA of Japan)

**17753** COMPARISON OF MEASUREMENTS OF THE TOTAL ELECTRON CONTENT BY THE FARADAY EFFECT AND IONOSPHERE SOUNDINGS. Thomas, G. (Faculte des Sciences, Paris). Planet. Space Sci.; 17: 2030-2(Dec 1969). (In French).

Both methods were used in order to obtain a complete profile. The results given by each method were compared, and it was found that the percentages of variation between the two electron content values were not greater than 14% and, in some cases, not more than 10%. (UK)

**17754** INITIAL DECELERATION OF SOLAR WIND POSITIVE IONS IN THE EARTH'S BOW SHOCK. Neugebauer, Marcia (California Inst. of Tech., Pasadena). J. Geophys. Res.; 75: 717-33(1 Feb 1970).

High time resolution ($\Delta t = 0.288$ to 9.5 seconds) plasma measurements were made on the upstream edge of the Earth's bow shock by the combination of a Faraday cup with modulation grid and a curved-plate analyzed on the satellite OGO 5. These observations show that the solar-wind positive ions often undergo a substantial deceleration just upstream of the shock's steep gradient of magnetic-field strength. This deceleration, which is not necessarily accompanied by a temperature increase, may be caused by a charge-separation electric field on the upstream side of the bow shock. (auth)

**17755** EFFECTS OF SUDDEN COMMENCEMENTS ON SOLAR PROTONS AT THE SYNCHRONOUS ORBIT. Paulikas, G. A.; Blake, J. B. (Aerospace Corp., El Segundo, Calif.). J. Geophys. Res.; 75: 734-42(1 Feb 1970).

Increases in solar proton flux coincident with sudden commencements have been observed by detectors aboard the geostationary ATS-1 satellite during 1967 and 1968. The flux increases are of short duration (<30 min) and are of magnetospheric origin. Decay of the proton flux after the sudden commencement enhancement (sce) is consistent with pitch-angle scattering by hydromagnetic waves. (auth)

**17756** GEOMETRY OF THE GEOMAGNETIC TAIL. Behannon, Kenneth W. (Goddard Space Flight Center, Greenbelt, Md.). J. Geophys. Res.; 75: 743-53(1 Feb 1970).

An analysis of magnetic field measurements in the geomagnetic tail from Explorers 33 and 35 during 1967–1968 has shown that there is a broad region of depressed-field magnitude approximately 12 $R_E$ thick and centered on the neutral sheet. The solar magnetospheric $B_z$ component is proportionately larger within that region than outside of it. $B_z$ is found to decrease with distance from the earth but to be positive on the average within the depressed field region out to a distance of 70 $R_E$, indicating that although for short periods of time the neutral line may be closer to the earth than the orbital distance of the moon, on the average it is beyond that distance. A negative $B_z$ component was found in ⅔ of the measurements outside the depressed field region. This analysis has shown that the magnetotail field diverges from the tail axis with distance from the earth. This result, together with the $B_z$ observations, supports a geometry in which for large $|Z_{sm}|$ the tail field is diverging in the $Z_{sm}$ as well as the $Y_{sm}$ direction, but is converging slightly toward the neutral sheet within the depressed field region. The combination of expanding tail and reconnection at the neutral sheet can account for the observed tail field magnitude gradient. The Explorer 33 and 35 measurements also indicate that the average angle between the tail axis and the Earth–Sun line is $3.1° \pm 1.5°$. (auth)

**17757** OGO 3 OBSERVATIONS OF ELF NOISE IN THE MAGNETOSPHERE. 2. THE NATURE OF THE EQUATORIAL NOISE. Russell, Christopher T. (Univ. of California, Los Angeles); Holzer, Robert E.; Smith, Edward J. J. Geophys. Res.; 75: 755-68(1 Feb 1970).

An examination of the noise present between 1 and 1000 Hz at the magnetic equator with the OGO 3 search coil magnetometer revealed a previously unobserved class of signals existing only in the outer plasmasphere. These waves are propagating nearly perpendicular to the magnetic field, probably within less than 1° of perpendicular to it; they exist only between about twice the proton gyrofrequency and half the lower hybrid resonant frequency. The waves are confined to a region within about 2° of the equator and therefore have a large amplitude gradient along the magnetic field lines. They are resonant with harmonics of the electron bounce frequency and have sufficient amplitude (~10 m$\gamma$ rms) to cause the observed pitch-angle diffusion of electrons mirroring near the equator. (auth)

**17758** PLASMA TEMPERATURES IN THE MAGNETOSPHERE. Sanatani, S.; Hanson, W. B. (Univ. of Texas, Dallas). J. Geophys. Res.; 75: 769-75(1 Feb 1970).

Rocket measurements of ion temperature are found to be in good agreement with the calculated values. It is shown that for low electron concentrations the ion temperature may be seriously underestimated when the boundary condition on ion heat transport is

imposed at too low an altitude. The opacity of the magnetosphere to photoelectrons is also examined, and it is concluded that small-angle Coulomb scattering may play an essential role in determining where the energy of these particles is dissipated. (auth)

**17759** HIGH-RESOLUTION STUDIES OF ELECTRONS 25 keV TO 2.7 MeV PRECIPITATING AT HIGH LATITUDES. Imhof, W. L.; Gaines, E. E.; Reagan, J. B. (Lockheed Palo Alto Research Lab., Calif.). J. Geophys. Res.; 75: 776-82(1 Feb 1970).

At high latitudes, quasi-trapped electrons (with minimum altitudes below sea level) were measured with high resolution in time and energy from a low-altitude polar-orbiting satellite. The data were taken during a period of low geomagnetic activity with several low-energy (>25 keV) detectors and a plastic scintillation spectrometer spanning the interval from 100 keV to 2.7 MeV with high sensitivity. Significant fluxes of quasi-trapped electrons were continually observed on several passes through the outer belt during this period. The intensities as a function of observation time were often rather steady but occasionally underwent appreciable changes on time scales as short as 50 msec (or distances of 400 meters). The quasi-trapped electrons were never observed to display a pronounced monoenergetic spectrum, nor a sharp spectral structure. (auth)

**17760** ROCKET-BORNE MEASUREMENTS OF Hβ EMISSIONS AND ENERGETIC HYDROGEN FLUXES DURING AN AURORAL BREAKUP. Wax, R. L.; Bernstein, W. (TRW Systems, Redondo Beach, Calif.). J. Geophys. Res.; 75: 783-7(1 Feb 1970).

Simultaneous rocket-borne measurements of the intensity and altitude profile of Hβ light emission and the flux and energy spectrum of 0.5- to 22-keV precipitated hydrogen were performed during an auroral breakup. The altitude of maximum Hβ emission was 130 km; the emission decreased rapidly at altitudes above the peak. The estimated total Hβ intensity was ~300 R ± 150 R, corresponding to an emission efficiency 0.25 photons $proton^{-1}$. The experimental results are compared with the theoretically predicted emission efficiencies and altitude profiles. (auth)

**17761** FAR-ULTRAVIOLET ALTITUDE PROFILES AND MOLECULAR OXYGEN DENSITIES IN AN AURORA. Opal, C. B.; Moos, H. W.; Fastie, W. G. (Johns Hopkins Univ., Baltimore). J. Geophys. Res.; 75: 788-96(1 Feb 1970).

The altitude profiles and absolute intensities of several far-ultraviolet emission features in a steady IBC I$^+$ aurora were measured with a filterwheel photometer carried in a Aerobee rocket over Churchill, Manitoba, at 2241 CST on February 8, 1968. The volume emission rate of the Lyman–Birge–Hopfield (LBH) system of $N_2$ was a nearly constant factor of 2.5 times the volume emission rate of 3914 A above 110 km; however, a falloff in this ratio, which possibly was the result of an abrupt change in the secondary electron energy spectrum at the lower border of the aurora, occurred below this altitude. The maximum intensity of the 1304-Å resonance triplet of O was twice the total intensity of the 3914-Å band of $N_2^+$ measured below the aurora. The brightness of the Lyman α line was 2.5 kR, and, although no auroral structure in the altitude profile of this feature was observed, there was a sudden 500 R increase in brightness that may have been caused by proton precipitation. The relative brightnesses of the far-ultraviolet features were about three times as large as previously reported. Molecular oxygen densities in the 110- to 120-km region were determined from the relative attenuation of LBH bands; the density at 115 km was $1.8 \times 10^{11}$ per $cm^3$, within a factor of 1.5. This value is somewhat higher than a previous absorption measurement and two recent mass spectrometer measurements that were also in the winter over Churchill. Taken together, the measurements indicate that winter $O_2$ densities near 115 km at high latitudes are at least a factor of 2 higher than those at temperate latitudes. (auth)

**17762** MAGNETOSPHERE MODEL BASED ON TWO ZONES OF PRECIPITATING ENERGETIC PARTICLES. Mishin, V. M. (IZMIRAN, Irkutsk, USSR); Saifudinova, T. I.; Zhulin, I. A. J. Geophys. Res.; 75: 797-806(1 Feb 1970).

Contrary to widely held ideas on the oval zone of precipitation of energetic particles into the Earth's atmosphere, the existence of two quasi-circular zones of precipitation was established several years ago on the basis of geomagnetic activity data. The two zones were found to be of quite a different nature. One of these zones, the higher-latitude one, has its maximum on the day side (latitude ~77°); the other zone, the lower-latitude one, has a considerably longer latitudinal extension and has its maximum on the night side (latitude ~67°). The concept of the oval zone as a single unified zone is not a necessary conclusion and could be a result of insufficient data or of incorrect data reduction. The same conclusion can also be reached on the basis of the analysis performed by Feldstein himself and on the basis of other direct and indirect data. In this paper the main features of two quasi-circular zones are presented on the basis of the instantaneous patterns of the distribution of geomagnetic activity as well as on the basis of the dynamics of these patterns. A magnetosphere model reflecting these features is presented. The suggested model links the lower-latitude zone with processes occurring in the magnetospheric tail, whereas the higher-latitude zone is connected with particle injection through the neutral points. (auth)

**17763** DETECTION OF CONJUGATE PHOTOELECTRONS AT MILLSTONE HILL. Evans, J. V. (Massachusetts Inst. of Tech., Lexington); Gastman, I. J. J. Geophys. Res.; 75: 807-15(1 Feb 1970).

Photoelectrons arriving in the F region from the conjugate point were detected at Millstone Hill during the winter night, by means of Thomsom scatter observations of the plasma lines that appear in the signal spectrum. During winter, when the solar zenith angle $\chi_0$ at the conjugate point is less than 100° throughout the night, the plasma lines are continuously present, provided that the local plasma frequency exceeds 4.0 MHz. For a few days in the spring the lines disappear for a period around midnight when $\chi_0 \geq 106°$. These observations confirm that photoelectrons can escape from one hemisphere into the other for L values as large as 3.2. The arriving flux appears to be too weak, however, to give rise to significant excitation of the 6300-Å line of atomic oxygen (J. F. Noxon, personal communication), which suggests that direct excitation may not be the main cause of the large predawn enhancements seen elsewhere. (auth)

**17764** PHOTOELECTRON FLUX AND PROTONOSPHERIC HEATING DURING THE CONJUGATE POINT SUNRISE. Rao, B. C. Narasinga; Maier, E. J. R. (Goddard Space Flight Center, Greenbelt, Md.). J. Geophys. Res.; 75: 816-22(1 Feb 1970).

Selected Explorer 31 data were studied to establish the extent of protonospheric heating by the onset of photoelectrons from the conjugate ionosphere. Observations made during low-latitude passes ($1.2 < L < 2.5$) at altitudes above 2000 km were analyzed to determine the electron and ion temperatures and the flux of photoelectrons for the periods when one foot of the field line is in darkness and the other is undergoing sunrise. In the night hemisphere there is an increase in electron temperature from about 1500° to 3500°K and in ion temperature from about 1500° to 3000°K and a simultaneous increase in suprathermal flux from about $2 \times 10^7$ to $15 \times 10^7$ electrons $cm^{-2}$ $sec^{-1}$ for electrons of energies greater than 3.7 eV. Observations also show an appreciable return flow of photoelectrons back into the sunlit hemisphere from the conjugate night hemisphere. Theoretical calculations of the energy and flux degradation of the photoelectrons along the field line are made and compared with the observations. Using the photoelectron energy loss as the energy input to the ambient plasma and using the steady-state heat conduction equation, the electron temperature profile along the field line is calculated. (auth)

**17765** DIURNAL VARIATION OF THE MEAN FARADAY FACTOR AT ARECIBO. Smith, D. H. (Cornell Univ., Ithaca, N. Y.). J. Geophys. Res.; 75: 823-8(1 Feb 1970).

Estimates of the total electron content of the ionosphere can be obtained from measurements of the Faraday rotation of vhf signals from a geostationary satellite. The accuracy of the estimates depends in part on the accuracy with which the mean value of the "Faraday factor" M, is known. A description is given of a method of calculating this factor by making use of the electron number density profiles obtained from a backscatter radar installation. For a 30-hour period of observation at Arecibo in January 1969, it is shown that $\bar{M}$ had a predawn minimum nearly 30% lower than its daytime maximum. The diurnal variation of $\bar{M}$ did not show an inverse dependence on the height of $h_{max}$. (auth)

**17766** ELECTRON-TO-ION TEMPERATURE RATIO FROM RADAR THOMSON SCATTER OBSERVATIONS. Wand, R. H. (Cornell Univ., Ithaca, N. Y.). J. Geophys. Res.; 75: 829-38 (1 Feb 1970).

Radar Thomson scatter observations made at the Arecibo Ionospheric Observatory on August 10, 1966, are reported. Analysis of the ion and plasma line components of the Thomson scatter signal from the ionosphere provided two essentially independent methods of obtaining the electron-to-ion temperature ratio $T_e/T_i$. In the first method, $T_e/T_i$ and $T_i$ were deduced from the shapes of the autocorrelation functions of the ion component by using assumed values for the ion composition. In the second method values of $T_e/T_i$ were derived from the radar equation for Thomson scatter using electron concentrations from the plasma line observations and power measurements of the ion component. Altitude profiles of $T_e/T_i$ from these two methods were compared over the range 130 to 450 km and were found to be in excellent agree-

ment. At 130 km $T_e/T_i$ was unity, and this result does not support the conclusion drawn from many midlatitude rocket observations that an E-region source of electron heating exists in addition to solar EUV. Above 130 km the electron temperature was always greater than the ion temperature for daytime conditions. A downward heat flux of $1.7 \pm 0.3 \times 10^9$ eV cm$^{-2}$ sec$^{-1}$ near local noon was inferred from the positive $T_e$ gradient at 400 km. The plasma line measurements provided accurate electron concentration ($n_e$) profiles in close agreement with simultaneous ionosonde determinations. Composite profiles of $T_e/T_i$, $T_i$, and $n_e$ are presented for different times throughout the day. (auth)

**17767** MEASUREMENT OF MOLECULAR OXYGEN CONCENTRATION BY ABSORPTION SPECTROSCOPY. Quessette, Jacques-Alain (CNRS, Verrieres le Buisson, France). J. Geophys. Res.; 75: 839-44(1 Feb 1970).

Two methods are compared to derive molecular oxygen concentration by absorption spectroscopy of the solar hydrogen Lyman-alpha line: a classical one, using a constant absorption cross section for $O_2$ in the vicinity of Lyman $\alpha$ and, another one, using a wavelength-dependent cross section. It is shown that the results differ slightly but that this difference cannot explain the abnormal absorption observed by the author between the altitudes 90 and 100 km. (auth)

**17768** POSSIBLE EXPLANATION OF AN ORDER OF MAGNITUDE DISCREPANCY IN ELECTRON-WAKE MEASUREMENTS. Samir, Uri (Univ. of Michigan, Ann Arbor). J. Geophys. Res.; 75: 855-8(1 Feb 1970).

In light of some recent electron-wake investigations made on the Explorer 31 satellite, it is suggested that the major part of the (1.5 to 2) orders of magnitude difference between the Explorer 8 and the Ariel 1 electron-wake measurements can be removed. (auth)

**17769** ON THE PRESENCE OF LOW-ENERGY PROTONS ($5 \lesssim E \lesssim 50$ keV) IN THE INTERPLANETARY MEDIUM. Frank, L. A. (Univ. of Iowa, Iowa City). J. Geophys. Res., 75: 707-16 (1 Feb. 1970).

A fortuitous set of observational conditions has allowed first measurements of low-energy proton ($5 \lesssim E \lesssim 50$ keV) distributions heretofore unobserved in the interplanetary medium. Salient features of the two major enhancements of interplanetary proton ($5 \lesssim E \lesssim 50$ keV) intensities observed during the period July 25 through August 13, 1967, were (a) a broad differential energy spectrum of intensities over the energy range $5 \lesssim E \lesssim 50$ keV with peak intensities ~10 protons (cm$^2$ sec sr eV)$^{-1}$ at ~20 keV, (b) peak number densities ~$10^{-2}$ protons (cm)$^{-3}$, (c) peak energy densities ~300 eV (cm)$^{-3}$, (d) an anisotropy in the angular distributions in the ecliptic plane favoring intensities arriving from near-solar directions by factors ~2 or 3, (e) duration of these events ~1 day on July 29 and August 11, and (f) the occurrence of a small geomagnetic storm immediately following each enhancement of proton intensities. These peak energy densities exceed the "quiet-Sun" ion and electron thermal energy densities by a factor ~10 and are comparable to or exceed these thermal energy densities during solar disturbances. The present observations at 1 AU are insufficient to determine whether these proton events are of solar origin or are the signatures of shock phenomena in the interplanetary medium during interplanetary storms. Sufficient energy is carried by these interplanetary protons ($5 \lesssim E \lesssim 50$ keV) to account for the observed $D_{st}$(H) decreases during the two small geomagnetic storms if ~2% of these protons incident upon the sunlit hemisphere of the magnetopause are convected into the earth's magnetosphere. The presence of these interplanetary proton intensities may be one of the important conditions for the development of main-phase geomagnetic storms. (auth)

**17770** THEORY OF ELECTRIC CURRENTS IN IONOSPHERIC E LAYERS. Cole, K. D. (La Trobe Univ., Victoria, Australia). Planet. Space Sci.; 17: 1977-92(Dec 1969).

The magnetic disturbance associated with east–west current in the ionosphere is calculated in terms of the production and loss of ionization. This is physically equivalent to a conventional equation of the type $j = [\sigma]E$, but may be preferred in many experimental circumstances. The relationship between the deformation of an ionospheric layer and the electric current, or magnetic disturbance in it, is explored in detail. Applications to mid-latitude sporadic E, the equatorial electrojet, night E, deformation of midlatitude E-layer by quiet and disturbed currents, and deformation of the E layer by auroral electrojets are considered. Under a wide range of conditions, vertical backscatter devices can be used to find the altitude profile of the east–west component of ionospheric electric current by measuring the deformations of the vertical profiles of electron density. (auth) (UK)

**17771** COMPARISON OF THE TOPSIDE IONOSPHERE DURING MAGNETIC STORMS OF VARIOUS TYPES. Arendt, P. R. (Army Electronics Command, Fort Monmouth, N. J.). Planet. Space Sci.; 17: 1993-5(Dec 1969).

During the initial phase of magnetic storms with steep onset, the topside ionosphere shows enhancement of ionization above the depletion below a zone of unchanged ionization. During storms with a smoothly initiated disturbance, no enhancement of ionization is observed and depletion takes place at all altitudes. (auth) (UK)

**17772** SECONDARY ELECTRONS IN AURORA. Rees, M. H. (Univ. of Colorado, Boulder); Stewart, A. I.; Walker, J. C. G. Planet. Space Sci.; 17: 1997-2008(Dec 1969).

The Bethe approximation is used with measured and theoretical values of ionization cross sections and measured values of differential oscillator strengths to derive the initial energy spectrum of auroral secondary electrons. The differential flux of the auroral secondaries is then calculated, using the approximation of continuous energy loss. The calculations are applied to a particular aurora for which rocket data have been published. There is substantial disagreement between theoretical and measured electron spectra. The theoretical spectra show structure energies less than 20 eV, associated primarily with vibrational and electronic excitation of molecular nitrogen. This structure is largely absent in the measured spectrum. Substantially more high-energy electrons were measured than theory predicts. In addition, there are disagreements in the altitude profiles of the total number of nonthermal secondary electrons. Calculated values of O I green line photon emission rates, which result from excitation by secondary electrons and dissociative recombination of $O_2^+$, fall short of the measured values. The effect on the excitation rate of varying several parameters is investigated, and it is found that the results are particularly sensitive to competing inelastic processes in $N_2$. (auth) (UK)

**17773** CYCLOTRON AMPLIFICATION OF GEOMAGNETIC MICROPULSATIONS Pci IN THE MAGNETOSPHERE. Jacobs, J. A.; Higuchi, Y. (Univ. of Alberta, Edmonton). Planet. Space Sci.; 17: 2009-16(Dec 1969).

A numerical analysis of cyclotron instabilities is carried out by computing the dispersion relation for a three-component cold plasma-beam system. Rates of growth and damping for various values of the stream density are calculated from the dispersion relation. The rates of growth and damping increase monotonically as the number density of the proton stream increases. It is found that the frequencies at the rates of maximum growth and the damping decrease slightly to lower frequencies and a sharp peak of these frequencies becomes blunt. The minimum e-folding times of an ion cyclotron wave for (a) $\sigma_s = 10^{-4}$, $\sigma_i = 10^{-2}$ and (b) $\sigma_s = 10^{-1}$, $\sigma_i = 10^{-2}$ are about 3.84 and 0.16 sec, respectively, in the vicinity of the equatorial plane at 6 $R_E$, where $\sigma_s$ and $\sigma_i$ are the ratios of the beam density $N_s$ and the helium ion ($He^+$) density $N_i$ to the total positive ions in the plasma–beam system. (auth) (UK)

**17774** DISTRIBUTION OF STABLY TRAPPED MAGNETOSPHERIC PLASMA AS DETERMINED FROM Pi2 MICROPULSATIONS AND THE AURORAL ELECTROJET INDEX, AE. Haurwitz, Marion W. (Inst. for Earth Sciences, Boulder, Colo.). Planet. Space Sci.; 17: 2017-23(Dec 1969).

The distribution of stably trapped plasma is determined as a function of equatorial geocentric distance, R. Observed Pi2 micropulsation periods and the magnitudes of their associated magnetic bays, measured by the auroral electrojet index, AE, are used in determining this distribution. Plasma density is found to vary inversely as approximately the sixth power of R. When Pi2 period–AE relations are studied for varying time lags, the pulsation periods are found to define prolonged intervals of abnormal AE levels. Thus the periods may be potentially useful in forecasting geomagnetic disturbances or abnormally quiet intervals. A qualitative physical model is proposed to explain the observational relations. (auth) (UK)

**17775** LATITUDINAL VARIATION IN $f_0F2$ CONJUGACY. Torr, Marsha R.; Torr, D. G. (National Inst. for Telecommunications, Johannesburg). Planet. Space Sci.; 17: 2025-6(Dec 1969).

The latitudinal variation in the degree of $f_0F2$ conjugacy was examined and the results compared with those obtained for nonconjugate pairs of stations. The analysis was performed, whenever possible, for sunspot maximum at equinox (April 1958). (UK)

**17776** EVIDENCE OF A RELATION BETWEEN THE DAWN CHORUS EMISSION AND PRECIPITATION OF ELECTRONS WITH ENERGIES BETWEEN 15 AND 150 keV. Kleimenova, Natalia; Maral, Gerard; Lacombe, Bernard; Vigneron, Jacques; Cambou, Francis (Groupe de Recherches Ionospheriques, Val-de-Marne,

France). Compt. Rend., Ser. B; 269: 846-9(29 Oct 1969). (In French).

The simultaneous analysis of vlf recordings and the energy flux of x rays due to precipitated electron bremsstrahlung shows that the rapid growth in the number of precipitated electrons is on one hand subsequent to the development of an elf emission, and on the other hand, simultaneous with the development of a dawn chorus emission. (tr-auth)

17777 DIURNAL MODEL OF THE E REGION. Keneshea, T. J.; Narcisi, R. S.; Swider, W. Jr. (Air Force Cambridge Research Labs., Bedford, Mass.). J. Geophys. Res.; 75: 845-54 (1 Feb 1970).

Detailed computer calculations of the electron, $O_2^+$, and $NO^+$ concentrations are provided for the E region on a diurnal basis. The present work contains the first continuous solution of these concentrations during sunrise and sunset. Comparison is made between this model and observations, particularly new results at sunrise and sunset. The model is compatible with the experimental data within a factor of 2, although some larger discrepancies occur. The nitric oxide distribution of Barth for altitudes 90 to 120 km appears to provide for the proper amount of conversion of $O_2^+$ into $NO^+$ via $O_2^+ + NO \rightarrow NO^+ + O_2$ and for an important twilight ionization source, H Ly $\alpha$ + NO $\rightarrow$ $NO^+$ + e. However, at 85 km, the model requires a lower concentration of nitric oxide than found by Barth in order to be consistent with the observed particle concentrations. The process $N(^2D) + O_2 \rightarrow NO + O$ is considered as a major NO-producing process in the E region. The most abundant atomic nitrogen species, $N(^4S)$, appears to play no role in the E region, except perhaps at 130 to 140 km. An upper limit of about $10^3$ $cm^{-3}$ is implied for atomic nitrogen. The calculations include H Ly $\beta$ as the main nighttime ionization source. It is stressed that the mean recombination coefficient of the E region appears to be larger at night than by day and largest at twilight. (auth)

17778 PROPAGATION OF MAGNETO-SOUND WAVES IN AN INHOMOGENEOUS MEDIUM. Brengauz, V. D. (Gorky State Univ., USSR). Ivz. Vyssh. Ucheb. Zaved., Radiofiz.; 12: 1455-60(1969). (In Russian).

The propagation of magnetosonic waves in isothermal magnetosphere is investigated in a linear approximation. The uniform magnetic field $H_0$ is directed parallel to the acceleration of gravity g. A fundamental solution of the equation describing the behavior of small displacements perpendicular to the magnetic field is found. The equation for the displacement parallel to the magnetic field is also found and analyzed. The fundamental solutions obtained are shown to involve the results of Ferraro and Plumpton (Astrophys. J., 127: 459(1958)) as partial cases. (auth)

17779 ON AN ELECTROMAGNETIC FIELD ARISING FROM AIR IONIZATION BY A POINT $\gamma$ SOURCE IN THE ELECTRIC FIELD OF THE EARTH. Gutop, Yu. V.; Medvedev, Yu. A. Ivz. Vyssh. Ucheb. Zaved., Radiofiz.; 12: 1573-6(1969). (In Russian).

Perturbation of the Earth's electric field from the air ionized by a point gamma source is theoretically treated. (auth)

17780 A STUDY OF THE INFLUENCE OF MAGNETIC ACTIVITY ON THE LOCATION OF THE PLASMAPAUSE AS MEASURED BY OGO 5. Chappell, C. R.; Harris, K. K.; Sharp, G. W. (Lockheed Palo Alto Research Lab., Palo Alto, Calif.). J. Geophys. Res.; 75: 50-6(1 Jan 1970).

The plasmapause position was measured quite well by the light ion mass spectrometer aboard OGO 5, which measures the concentrations of $H^+$, $He^+$, and $O^+$ ions as a function of L and local time. The influence of magnetic activity on this plasmapause position was studied for the local-time regions at 1000 ± 2 hours and 0200 ± 2 hours. The plasmapause location shows a general decrease in radius with increasing activity in both regions. The time lag between the onset of magnetic activity and the change in plasmapause radius is found to be about 2 to 6 hours for the 0200 local-time region. However, the time lag for the 1000 local-time region is not well defined, although the 6-hour lag time seemed to fit some of the cases better than the 12- or 24-hour periods that were examined. By using the 2- to 6-hour response time, the plasmapause density profiles in the 0200 local-time region were grouped according to magnetic activity. This grouping displays the typical plasmapause reaction in this local-time region to increasing magnetic activity with the knee position moving to lower L values, the sharpness of the knee increasing, and the total concentration levels inside and outside the knee remaining approximately the same at $10^3$ ions/$cm^3$ and 1 ion/$cm^3$, respectively. (auth)

17781 IONOSFERNYE ISSLEDOVANIYA. SBORNIK STATEI, NO. 15. REZUL'TATY ISSLEDOVANII PO MEZHDUNARODNYM GEOFIZICHESKIM PROEKTAM. (Ionospheric Researches. Articles, No. 15. Results of Researches on International Geophysical Projects). Verezin, Yu. V.; Nerovnya, L. K. (eds.). Moscow, Izdatel'stvo Nauka, 1968. 152p. (In Russian).

Various studies on ionosphere structural inhomogeneities and their movements during the IGY and IQSY are given. Separate abstracts were prepared for 10 papers. (W.D.M.)

*For abstracts of individual papers see: 17782–17791.*

17782 PECULIARITIES OF PLASMA MOVEMENTS FOR SOME SIMPLE MODELS OF IONOSPHERIC FORMATIONS. Rybin, V. V. pp 10-23 of Ionosfernye Issledovaniya. Sbornik Statei, No. 15. Verezin, Yu. V.; Nerovnya, L. K. (eds.). Moscow, Izdatel'stvo Nauka, 1968. (In Russian).

Major peculiarities of the movement of homogeneous cold plasma with a low degree of ionization under the effect of the surrounding electrostatic field and homogeneous current of neutral particles are discussed, with consideration of the influence of the regular magnetic field. The movement of regions, where the density of charged particles is greater than in the surrounding plasma, is discussed. (auth)

17783 DEPENDENCE OF DRIFT VELOCITIES ON RATIO OF TRANSVERSE DIMENSIONS FOR TWO-DIMENSIONAL MODEL OF IONOSPHERIC INHOMOGENEITIES. Rybin, V. V. pp 24-31 of Ionosfernye Issledovaniya. Sbornik Statei, No. 15. Verezin, Yu. V.; Nerovnya, L. K. (eds.). Moscow, Izdatel'stvo Nauka, 1968. (In Russian).

The movement of an infinite elliptic cylinder of cold plasma elongated along a magnetic field is discussed. Within this cylinder the density of charged particles is greater than in the surrounding homogeneous medium. The movement occurs in a homogeneous flow of neutral particles and in the surrounding electro- and magnetostatic fields. The data were obtained assuming that such configuration is the only balanced configuration (the form does not change with different orientations of the ellipse in the cross section and with any ratios of its axes). The velocity of the movement of the cylinder and the inner polarization of the electric field are computed, and the dependence of the velocity movement in the wind's direction on the form and relative density of charged particles in the inhomogeneity are discussed in detail. It is assumed that such a model can help to explain the dependence of the movement velocity of ionospheric formations of different nature on their form and orientation. This problem can be solved correctly only if the influence of the limitations of dimensions of real inhomogeneities is taken into account. (auth)

17784 CALCULATION OF ELECTRON–ION COLLISIONS IN THE MODELS OF MOVING IONOSPHERIC INHOMOGENETIES. Rybin, V. V. pp 32-9 of Ionosfernye Issledovaniya. Sbornik Statei, No. 15. Verezin, Yu. V.; Nerovnya, L. K. (eds.). Moscow, Izdatel'stvo Nauka, 1968. (In Russian).

The role of electron–ion collisions in the steady movements of ionospheric plasma is discussed, and it is shown that, due to the smallness of frequencies of collisions, compared with the gyrofrequencies, it becomes possible to use the formulas describing the movements of ionospheric irregularities without consideration of the electron–ion collisions in cases when these frequencies are of the same order or greater than the frequencies of collisions of charged particles with neutral. The same results were obtained by means of expressions for the anisotropic conductivity which take into account the electron–ion collisions. This conclusion is true only for the polarization electric field in inhomogeneities and for the drift velocities. The electron–ion collisions have a considerable effect on the movement of the electrons and ions. Besides, this conclusion is not true for very strong ionized formations where the frequencies of mutual collisions of charged particles can be compared to gyrofrequencies. (auth)

17785 DRIFT OF IONIZATION INHOMOGENEITIES IN F REGION OF THE IONOSPHERE OVER ASHKHABAD. Dzhemilev, G. G.; Vasil'eva, E. K.; Rozentsveig, B. D.; Maksimenko, O. I.; Chervyakova, A. F. pp 40-50 of Ionosfernye Issledovaniya. Sbornik Statei, No. 15. Verezin, Yu. V.; Nerovnya, L. K. (eds.). Moscow, Izdatel'stvo Nauka, 1968. (In Russian).

Results of drift studies of small-scale inhomogeneities in the F2 region over Ashkhabad during the maximum and minimum periods of solar activity are presented. A comparison of drift characteristics of inhomogeneities is carried out for the indicated periods. The diurnal and seasonal variations of direction and magnitude of drift velocity are analyzed. First results of a study of the altitude dependence of drift velocity in the F2 layer are presented. (auth)

17786 DRIFTS IN THE F2 REGION OVER MOSCOW IN THE IGY AND IQSY PERIODS. Kashin, A. A.; Kushnerevskii, Yu. V.; Nerovnya, L. K.; Andreev, E. G.; Zagulyaeva, V. A. pp 51-4 of Ionosfernye Issledovaniya. Sbornik Statei, No. 15.

Verezin, Yu. V.; Nerovnya, L. K. (eds.). Moscow, Izdatel'stvo Nauka, 1968. (In Russian).

The results of researches of the ionospheric plasma drift in the F2 layer over Moscow during the IGY and IQSY periods are compared. The general similarity in the behavior of ionospheric drifts is emphasized. It is shown that during the IQSY the value of the drift velocity is somewhat greater than during the IGY. In 1964 the occurrence of a more considerable N–S component of the drift was observed, compared with 1957. (auth)

17787 DRIFTS IN THE F2 REGION IN THE IGY AND IQSY PERIODS. Zagulyaeva, V. A.; Kushnerevskii, Yu. V. pp 55-64 of Ionosfernye Issledovaniya. Sbornik Statei, No. 15. Verezin, Yu. V.; Nerovnya, L. K. (eds.). Moscow, Izdatel'stvo Nauka, 1968. (In Russian).

Results are presented of a comparison of data on the drift of small-scale inhomogeneities in the F2 layer obtained during the IGY and IQSY (1964) according to observations at the stations in the Soviet Union. It was determined that the general characteristics of the drift do not change depending on the magnitude of solar activity. The presence in 1964 of a greater north–south drift component than in the IGY period is noted. (auth)

17788 RESULTS OF RESEARCHES OF PARAMETERS OF SMALL-SCALE INHOMOGENEITIES OF THE IONOSPHERE IN ANTARCTICA. Kashin, A. A.; Klimanov, F. P.; Nerovnya, L. K. pp 65-8 of Ionosfernye Issledovaniya. Sbornik Statei, No. 15. Verezin, Yu. V.; Nerovnya, L. K. (eds.). Moscow, Izdatel'stvo Nauka, 1968. (In Russian).

Results of studies of the drift of small-scale inhomogeneities in the ionosphere in the region of the observatory Mirny (Antarctica) for 1963 are presented. The processing of data was carried out by the similarity method and by the method of correlation analysis. Great velocity changes according to size and stability of drift by direction in any season of the year are noted. The similarity of the general regularities of the small-scale inhomogeneities' drift is observed in the E and F2 layers of the ionosphere. A dependence of drift velocity on "K" index of magnetic activity is obtained for the F2 layer of the ionosphere. (auth)

17789 DRIFT OF SMALL-SCALE INHOMOGENEITIES IN THE F2 REGION ACCORDING TO OBSERVATIONS IN LOPARSKAYA. Sadovnikova, R. S. pp 69-73 of Ionosfernye Issledovaniya. Sbornik Statei, No. 15. Verezin, Yu. V.; Nerovnya, L. K. (eds.). Moscow, Izdatel'stvo Nauka, 1968. (In Russian).

Results are presented of observations of drift of small-scale inhomogeneities in the F2 layer for the period 1961–1965, as well as a comparison with results obtained in 1958–1960. The authors studied the seasonal and diurnal changes of velocity and direction of drift. It is noted that the drift velocity changes within a very wide range 40 to 400 m/sec, the most probable value is about 100 m/sec. The direction of the drift is primarily east and west. In the years of maximum solar activity the drift velocities were somewhat greater than in the years of minimum. The dominating directions did not undergo any considerable changes. (auth)

17790 DRIFT OF INHOMOGENEITIES IN THE $E_s$ LAYER. Yakubovich, G. P. pp 74-6 of Ionosfernye Issledovaniya. Sbornik Statei, No. 15. Verezin, Yu. V.; Nerovnya, L. K. (eds.). Moscow, Izdatel'stvo Nauka, 1968. (In Russian).

The results of a study of movements of inhomogeneities in the $E_s$ layer revealed a considerable scattering of values of drift velocities. The measured values of velocity are within the range of 40 to 280 m/sec. The analysis of the altitude dependence of drift characteristics showed considerable changes of velocity and direction of drift with height. (auth)

17791 DIURNAL VARIATIONS OF FLUCTUATIONS OF THE ELECTRON DENSITY IN THE IONOSPHERE OF THE NORTHERN HEMISPHERE. Kazimirovskii, E. S.; Kokourov, V. D.; Ppaushina, L. B. pp 77-84 of Ionosfernye Issledovaniya. Sbornik Statei, No. 15. Verezin, Yu. V.; Nerovnya, L. K. (eds.). Moscow, Izdatel'stvo Nauka, 1968. (In Russian).

An attempt is made to connect the appearance of the so-called F scatter with large-scale fluctuations of the electron density in the F region of the ionosphere. The analysis of data obtained at several ionospheric stations allowed to construct for the northern hemisphere a "map" of global variations of the P index, which is proportional to the fluctuations of the electron density. Characteristic zones of fluctuations for magnetically quiet and magnetically disturbed days are revealed. (auth)

17792 PROBING THE IONOSPHERE WITH INCOHERENT SCATTER: A NEW RADIO TECHNIQUE. du Castel, Francois (Centre Nationale d'Etudes des Telecommunications, Issy-les-Moulineaux, France). Sci. Forum; 2: 23-5(Oct 1969).

Results of ionospheric studies conducted with the incoherent scatter technique are reviewed. Initially, the new technique was used mainly for a morphological description of ionospheric parameters, some observed for the first time. Measurements of the concentration, temperatures, and chemical composition of the ionization in the altitude range 100 to 600 km were made continuously over periods of days, and gave the basis for future developments in the understanding of the ionosphere and its dynamics. Now, attention of scientists is being focused on specific phenomena. Temperature data are used to deduce heat production sources and to follow the exchange of heat among the various atmospheric constituents (ionized and neutral particles). A new phenomenon has been detected along the lines of force of the geomagnetic field. Some simultaneous optical observations of associated light emissions have confirmed the existence of photoelectrons also from the opposite hemisphere. Another field of research opened by the availability of the new data is the ionization balance of the medium. It involves chemical reactions in the ionosphere very poorly understood until now. It also requires consideration of the motions of the ionization which are partly available now that ion winds are being measured. These wind measurements have led to the discovery of the existence in the upper ionosphere during disturbed days of gravity wave effects that previously were suspected from theory but never so clearly detected by experiment. (BBB)

17793 DISTRIBUTION OF SSC SIZES AT ALIBAG FOR THE PERIOD 1921–1960. Sastri, N. S.; Jayakar, R. W. (Colaba Observatory, Bombay). Indian J. Meteorol. Geophys.; 20: 129-34(Apr 1969).

Intensities of ionospheric storms of sudden commencement (SSC) were examined on the basis of the magnitude of their horizontal component, H. The seasonal and annual distributions of frequency of occurrence at Alibag of SSCs of different sizes of the main impulse in H and the distribution of the mean sizes were studied. There were in all 813 SSCs. The largest value in H of SSCs recorded during the period is 280 $\gamma$ on July 8, 1928 at 03 hr 02 min local mean time (LMT). A list of SSCs of large size ($\geq$75 $\gamma$) is given in a table. Large values of H are distributed equally in number during day and night hours, but those occurring during the night are larger. The average for the SSCs occurring during the night is 138 $\gamma$ and of those occurring during the day is 91 $\gamma$. Of the eighteen SSCs enumerated, seven occurred in the month of July, of which five were of comparatively larger sizes and occurred during the nighttime. The bi-hourly mean values of SSCs were thus found to be larger in magnitude on either side of midnight and lower during the daytime with a minimum in the interval 4 to 6 hr LMT. The annual mean size of SSCs in the solar cycle follows the annual mean Zurich sunspot number in a general way. (BBB)

17794 TIME VARIATIONS OF ALIBAG K INDICES (1946–1965). Yacob, A.; Rangarajan, G. K. (Colaba Observatory, Bombay). Indian J. Meteorol. Geophys.; 20: 135-40(Apr 1969).

Analysis of time variations of ionospheric K-indices for the period 1946 to 1965 in Alibag confirmed the occurrence of a daytime maximum in summer and nighttime maximum in the equinoxes and winter. Average magnitude of K index at each of the 3-hr intervals, for which K indices are scaled, depicts a semi-annual trend with equinoctial maxima. This semi-annual variation is particularly prominent around midnight. Annual trends in equivalent daily range amplitude, $A_K$, for Alibag show clear equinoctial maxima for both IQ and ID days of the years 1952–54. No clear semi-annual variation in $A_K$ is seen during sunspot active periods of 1955 to 1957 and 1958 to 1960. Power spectra of $A_K$ depicts also rotation periodicities for the years around the sunspot minimum year 1954. This periodicity is much less prominent during the years around sunspot maximum. The observed features are discussed. (auth)

17795 SECULAR VARIATION OF GEOMAGNETIC ELEMENTS AT ALIBAG. Rao, D. R. K.; Bansal, R. K. (Colaba Observatory, Bombay). Indian J. Meteorol. Geophys.; 20: 141-4(Apr 1969).

Attempts were made to represent secular variations of geomagnetic elements (H, Z, and D) of data for Alibag by fitting polynomials of third order to the observed annual mean values for the years 1905–65. The coefficients of the fitted curve accounted for more than 99% of the total variation in case of H and D and 98% in case of Z. The coefficients are compared with those computed by Moos, Pramanik, and Pramanik and Ganguli for the same station. A probable change of position or intensity, or both, of the focus of the H-field in the region is inferred from the change in trend of H and D curves about the year 1964. The residual H, Z, and D curves did not show any parallel with solar activity as judged from sunspot numbers. H and Z residuals nearly indicated a periodicity of three solar cycles whereas D showed a periodicity of two solar cycles. (auth)

17796 IONOSPHERIC PHASE DISTORTION AND FARADAY ROTATION OF RADIO WAVES. Murakami, T.; Wickizer, G. S.

(RCA Missile and Surface Radar Div., Moorestown, N. J.). RCA Rev.; 30: 475-503(Sep 1969).

The propagation effects to be expected in wideband transmission of radio waves through the ionosphere are examined and these effects are related to the condition or state of the ionosphere. The pertinent characteristics of the ionosphere are given and the procedure used to calculate the phase distortion and Faraday rotation caused by the ionosphere on a radio wave is illustrated. The influence of solar activity and the seasonal and diurnal variations of electron density are considered. Although the phase-path delay and the group-path delay vary inversely as the square of the frequency, the corresponding phase shifts vary inversely as the frequency. The distortion produced by the phase-path and group-path delays is opposite in sign and the relative net phase distortion is predominantly parabolic in nature, which produces FM-type distortion if the signal used has a significant bandwidth. At a frequency of 3350 MHz, the calculated Faraday rotation was shown to be relatively small and its effect can be minimized by proper choice of signal observation time. (auth)

**17797** A STUDY OF THE INTERACTION OF ELECTROSTATIC AND ELECTROMAGNETIC WAVES WITH THE LOSS-CONE PARTICLE DISTRIBUTION TRAPPED WITHIN THE EARTH'S MAGNETOSPHERE. Bird, Harvey Harold. Hoboken, N. J.; Stevens Inst. of Tech. (1969). 99p.

Thesis.

The interaction is initially studied of longitudinal waves (propagating at an angle to a uniform magnetic field) with a loss-cone plasma of relativistic electrons moving against a fixed neutralizing ion background. By means of a Nyquist analysis of the dispersion relation, it is found that electrostatic oscillations whose growth rates significantly exceed the electron cyclotron frequency cannot exist. If, however, the ions are free to move, such as is the case for the charged particle population residing within the earth's magnetosphere, then the plasma can support electrostatic oscillations whose growth rates significantly exceed the electron cyclotron frequency. It is reasoned that these growth rates must depend in an essential way on the ion plasma frequency, and hence increase with increasing particle density. The interaction is then studied of transverse waves (propagating parallel to a uniform magnetic field) with the particles described by a double-humped velocity-space distribution function which is loss-cone limited. Such a distribution function can represent the magnetospheric plasma whose energetic secondary hump is observed to be roughly isotropic except for the loss-cone. A Nyquist analysis of the dispersion relation shows initially that any plasma which is isotropic except for the loss-cone can be unstable to transverse waves. Growth (damping) rates are then obtained in terms of the mirror ratio R and the details of the particle distribution function for each species. These results are then specialized for the case of a double-humped isotropic loss-cone velocity distribution. By treating the thermal component as effectively cold, it is found that the relatively small energetic component of the secondary hump can introduce, if sufficiently monoenergetic, additional electromagnetic instability not otherwise present for monotonic distributions. The actual particle distribution observed within the magnetosphere is then considered, and the results of numerical computations of damping rates are presented. (Diss. Abstr. Int., B)

**17798** DETERMINATION OF F-REGION VERTICAL DRIFTS AT MILLSTONE HILL. Evans, J. V. (Massachusetts Inst. of Tech., Lexington); Brockelman, R. A.; Julian, R. F.; Reid, W. A.; Carpenter, L. A. Radio Sci.; 5: 27-38(Jan 1970).

Thomson scatter observations of the F region at altitudes between 450 and 900 km are described; from them the bulk vertical velocity of the ambient electrons can be determined. These measurements were made possible by the construction of a new spectrum analyzer; they supplement earlier established programs to measure F-region densities and temperatures at Millstone Hill. The uncertainty in the results varies both with time of day and with altitude but is of the order of ±5 m/sec. Sample results are presented which show evidence of (1) thermal expansion and contraction of the layer and (2) oscillatory fluctuations attributed to traveling ionospheric distrubances. (auth)

**17799** IRREGULARITIES IN IONIZATION OF THE NIGHTTIME D REGION DEDUCED FROM VERTICALLY INCIDENT VLF RADIO WAVES. Gossard, Earl E. (Naval Electronics Lab. Center, San Diego, Calif.). Radio Sci.; 5: 7-17(Jan 1970).

Results of a spaced-receiver experiment using several very low radio frequencies to probe the irregular structure of the lower ionosphere at night are presented. A multiple frequency-sounding facility was used whose transmissions were received via a nearly vertically incident first-hop sky wave. Some of the statistical characteristics of the phase and amplitude fluctuations in the diffraction pattern at the ground are described. The data are compared with a theoretical analysis of the diffracting properties of an irregular screen [Bowhill, 1961] to determine the feasibility of using a single receiver near a standard vlf transmitter to continuously monitor the scale size of the irregularities in the nighttime D region by measuring the phase and amplitude of the first-hop sky wave. Some implications are pointed out regarding the functional forms of the spatial spectrum and the correlogram of the irregularities at the height of reflection. (auth)

**17800** ON ONE POSSIBLE MECHANISM FOR FORMATION OF INHOMOGENEITIES IN INTERPLANETARY PLASMA. Kotsarenko, N. Ya.; Koshevaya, S. V.; Yukhimuk, A. K. (Inst. of Geophysics, Kiev). Ukr. Fiz. Zh.; 14: 2048-51(Dec 1969). (In Russian).

One of possible mechanisms for formation of an inhomogeneous structure of interplanetary plasma is under discussion. The mechanism is due to instability of electron flows moving by helical trajectories along force lines of the interplanetary magnetic field. Characteristic dimensions of unstable perturbations l are shown to be located within the range of $1.2 \times 10^7$ to $2 \times 10^8$ cm. (auth)

**17801** COLLISIONAL COUPLING OF NEUTRAL- TO PLASMA-ACOUSTIC WAVES IN A DIFFUSE LAYER. Woo, James C.; Kahalas, Sheldon L. (Mt. Auburn Research Associates, Inc., Cambridge, Mass.). Phys. Fluids; 13: 712-20(Mar 1970).

If a neutral–acoustic wave propagates into an inhomogeneous, partially ionized region whose particle density is decreasing and whose ionization density (starting from zero) is increasing in the direction of propagation, then the neutral–acoustic wave, propagating in the neutral component of the gas, excites an ion–acoustic wave by collisional coupling. If the neutral gas and plasma are in thermal equilibrium, the two waves are in phase, so that an ion wave of significant amplitude will be excited, while the neutral wave is strongly dispersed. The ion wave amplitude has a maximum in the frequency domain at a period of about 1 min, consistent with experimental observations of certain traveling disturbances in the lower ionosphere. (auth)

**17802** PROBLEMS ABOUT GEOMAGNETIC CONJUGATE POINTS (WAVE PROPAGATION). Yamaoka, Makoto (Radio Res. Lab., Tokyo). Denpa Kenkyusho Kiho; 15: 243-8(May 1969). (In Japanese).

Recent investigations on the wave propagation and duct echo between geomagnetic conjugate points were reviewed. First, results obtained by ray tracing methods were summarized. Leakage of radiowaves with frequency below half the minimum gyrofrequency was shown by ray tracing. Observation by artificial satellites was in qualitative agreement with the theory. The appearance of echoes between conjugate points in the MF band was statistically analyzed. It was shown that the frequency of occurrence is not much affected by geomagnetic index, $K_p$. Its relation to L was shown and discussed. The frequency of occurrence with respect to local time and the day of the year was shown. Variations with periods 1.75 hour and 14.8 days were found. From these variations a model of duct formation in the magnetosphere was illustrated. Observations using artificial satellites that would give valuable information were proposed. (NSA of Japan)

**17803** INFLUENCE OF THE MAY 20, 1966 SOLAR ECLIPSE ON THE SPORADIC E LAYER. Samardzhiev, Dimitr; Serafimov, Kiril. Izv. Geofiz. Inst., Bulg. Akad. Nauk; 15: 111-28(1969). (In Bulgarian).

On the day of the eclipse, as well as during the control period, in both stations a sporadic layer is regularly observed. The mean day-time values of the boundary frequencies $fE_s$ during the control period show a cosine dependency with an exponent which has a value for Michurin 0.32, and for Sofia 0.26. On the day of the eclipse before the 1st contact the frequencies $fE_s$ also submit to this cosine dependency. The shadowing of the solar disk after the first contact and respectively the decrease of the ionizing radiation leads to a significant decrease of the boundary frequencies $fE_s$, as well as of the blanketing frequencies $f_bE_s$. In different moments of the eclipse $fE_s$ and $f_bE_s$ fall under the minimal frequencies observed in the control period. It is established that the variations of the boundary and blanketing frequencies are determined by a radiation, coming from the homogeneous solar disk, as well as from the uncovered part of the corona. It is obtained that the contribution in the ionization state of the $E_s$ layer of the homogeneous disk is about 75%, and 25% is due to radiation of the corona nonhomogeneities. The influence of the local sources on the solar disk and corona on $fE_s$ and $f_bE_s$ is established. Such a source on the day of the eclipse is the D13-region whose shadowing provokes a significant fall of $fE_s$ and $f_bE_s$ before the maximum phase, and its opening—a corresponding increase. After the maximum phase the Moon shadow covers more active regions on the disk (for example the whole C group, the most intensive parts

of the D-region and A1, etc.). This is the ionization cause for the top and blanketing frequencies fall. The obtained influence of the inhomogeneous corona on the boundary frequencies of the $E_s$ layer (about 25%) is the same with that one for the critical frequencies of the normal E-layer. This gives grounds to suppose that the sporadic E-layer develops in the round maximum part of the normal E layer. The identical influence of the coronal region on $fE_s$ and $f_0E$ and the condition that $fE_s$ frequencies depend more strongly than $f_0E$ on the nonhomogeneities on the disk and in the corona, indicate an important dependency of the top frequencies of the $E_s$ layer on the soft x-ray radiation (mainly in the range 44 to 60 Å, where the x-ray intensity maximum is). An important result of the comparison of the diurnal variations of $fE_s$ during the eclipse is the confirmation of the "sunset" effect existence in the sporadic layer development. The small increase of $fE_s$ a little after the 1st contact, which in a different degree is observed in both stations, reflects this "sunset" effect directly. (auth)

**17804** DEVIATING AND NONDEVIATING ABSORPTION OF THE RADIO WAVES IN THE MIDDLE IONOSPHERE. Serafimov, Kiril. Izv. Geofiz. Inst., Bulg. Akad. Nauk; 15: 95-109(1969). (In Bulgarian).

On the basis of contemporary information for the dependency of the effective frequency of collisions between electrons and neutral particles, and between electrons and ions, an approximate expression is derived for the height distribution of $\nu$ in the E-layer, and new data are obtained for $\nu(z)$ up to 170 km. The non-deviating absorption in a simple layer is analyzed at $\nu \sim e^{-p\sqrt{z}}$ and a new expression for this absorption in a parabolical layer is derived. The non-deviating absorption in two equivalent simple layers — E and F1 is considered. Expressions for the non-deviating absorption in simple and parabolical layer are derived at $\nu \sim e^{-p\sqrt{z}}$ and $\nu \approx$ const. At the end some data are given for the non-deviating and deviating absorption between 100 and 170 km over Bulgaria and Europe. The non-deviating absorption in the E-layer in general outline follows the variations of the maximal electron concentration $N_mE$, but some of the peculiarities of the latter (for ex. preculmination hindrance in the growing, day-time asymmetry, etc.) are underlined in the variations of $L_nE$. The non-deviating absorption in the intermediate E – F region has non-neglected values and can be used for structural investigations. The deviating absorption in the E-layer is a variable value which reaches significant values (for winter on frequency 3.86 MHz at mean activity $L_nE \approx 3.2$ dB). The middle ionosphere gives 1/3 of the half of the short waves absorption. (auth)

**17805** LUNAR CONDUCTING ISLANDS AND FORMATION OF A LUNAR LIMB SHOCK WAVE. Hollweg, Joseph V. (Max-Planck-Institut fuer Physik und Astrophysik, Munich). J. Geophys. Res.; 75: 1209-16(1 Mar 1970).

A mechanism is proposed for the creation of a weak solar-wind shock at the lunar limb, in which the fluctuating interplanetary magnetic field interacts with a thin highly conducting crust. The crust is assumed to be fractured and describable in terms of what is called conducting islands. The fluctuating interplanetary field produces currents inside the conducting islands, which in turn produce magnetic fields capable of deflecting the solar wind. It was found that conductivities of $4 \times 10^{-4}$ mho/m and crust thicknesses of 5 km are consistent with the observed 3° to 6° flow deflection if the "fractionation scale" is of the order of 400 km. Higher conductivities and greater thicknesses imply a smaller fractionation scale. (auth)

**17806** VELA 4 PLASMA OBSERVATIONS NEAR THE EARTH'S BOW SHOCK. Montgomery, Michael D.; Asbridge, J. R.; Bame, S. J. (Los Alamos Scientific Lab., N. Mex.). J. Geophys. Res.; 75: 1217-31(1 Mar 1970).

Concurrent measurements of electron and proton differential energy spectrums (each spectrum measurement requiring from 0.1 to 0.3 sec) have been obtained near the earth's bow shock with the Vela 4B electrostatic analyzer. The following results have been derived from an analysis of 26 shock crossings during May and June 1967: (1) The jump in proton temperature is 2 to 4 times greater than the jump in electron temperature. (2) In the magneto-sheath the proton temperature is nearly always greater than the electron temperature. (3) $T_e/T_p$ upstream from the shock ranges between 0.6 and 4, and the shock remains well defined over this range. (4) Electron thermalization usually occurs in much less than 3 sec and has been observed to occur in ≈0.03 sec. (5) The magnetosheath electron velocity distribution is flat-topped or sometimes somewhat concave in shape within at least a few $R_E$ of the shock. (6) Evidence has been found that electrons are thermalized in a thin region upstream from the region in which most of the proton thermalization occurs. The observed increase in $T_e/T_p$ resulting from electron preheating may account for destabilization of electrostatic ion waves that may then produce strong ion heating by nonlinear Landau damping. Representative proton and electron velocity distributions from which the above results were derived are presented. (auth)

**17807** MAGNETIC MEASUREMENTS IN THE EARTH'S MAGNETOSPHERE AND MAGNETOSHEATH: MARINER 5. Smith, Edward J. (California Inst. of Tech., Pasadena); Davis, Leverett Jr. J. Geophys. Res.; 75: 1233-45(1 Mar 1970).

Magnetic field measurements near earth, obtained by a vector helium magnetometer on board Mariner 5, indicate that inside the magnetosphere there are waves with modest amplitudes (~2 to 3$\gamma$) and periods near 5 minutes that have components both transverse and parallel to the ambient field. The distant magnetospheric field involves a simultaneous compression and twisting of field lines similar to those observed previously on earth satellites. Some features of the distorted field, such as an apparent reversal in field gradient approaching the magnetopause and nearly equal field magnitudes in the magnetosphere and magnetosheath, show poor qualitative agreement with a simple Chapman–Ferraro model and imply either changes with time or a complicated structure. The absence of a significant field component normal to the magnetopause, however, is consistent with a closed magnetosphere. Multiple magnetopause crossings that imply a quasi-sinusoidal surface motion with a peak to peak amplitude of ~1/3 earth radii, a period of ~2 min, and a peak velocity of ~50 km $sec^{-1}$ are observed. In the magnetosheath, adjacent to the magnetopause, a train of nonsinusoidal waves having the appearance of Alfvén waves are observed with amplitudes of ~5$\gamma$ and periods of ~2 min, oscillating essentially in a plane parallel to the magnetopause. A region of highly disturbed irregular fields with $\Delta B/B \sim 1$ when $B \approx 30\gamma$ is observed for ~1 hour in the magnetosheath well inside the shock and is presumably associated with changing conditions in the solar wind. The directions normal to the magnetopause and shock, derived from the magnetic fields adjacent to those boundaries, agree well with the corresponding directions based on the average shapes of the two surfaces. (auth)

**17808** TIME HISTORY OF THE INNER RADIATION ZONE, OCTOBER 1963 TO DECEMBER 1968. Bostrom, C. O.; Beall, D. S.; Armstrong, J. C. (Johns Hopkins Univ., Silver Spring, Md.). J. Geophys. Res.; 75: 1246-56(1 Mar 1970).

Data from electron and proton detectors aboard satellite 1963 38C have been studied for the time period from September 1963 through December 1968. Detector energy ranges in MeV are: $E_e \geq 0.28$; $E_e \geq 1.2$; $1.2 \leq E_p \leq 2.2$; $2.2 \leq E_p \leq 8.2$; $8.2 \leq E_p \leq 25$; $25 \leq E_p \leq 100$. The region to be discussed is $1.2 \leq L \leq 3.0\ R_E$ over the B range accessible to the satellite in an 1100-km circular polar orbit. For high-energy electrons (≥1.2 MeV) the major feature has been the steady decay of the artificial belt. By the end of 1968 Starfish electrons had essentially disappeared, and there is no indication of a natural source for electrons with energy ≥1.2 MeV. The low-energy (≥0.28 MeV) electron flux has been near enough to the natural levels since early 1966 to reveal the effect of natural events; these electrons undergo significant changes throughout the inner zone in response to major magnetic storms. In particular, the events in September 1966, May 1967, and November 1968 produced large changes in the low-energy electrons and also in low-energy protons, although the protons responded over a more limited region of L space. (auth)

**17809** INJECTION OF PROTONS INTO THE RADIATION BELT BY SOLAR NEUTRON DECAY. Claflin, E. Scott; White, R. Stephen (Univ. of California, Riverside). J. Geophys. Res.; 75: 1257-62(1 Mar 1970).

The coefficient $\chi$ for injecting protons into the earth's radiation belt by solar neutron decay (SND) is calculated as a function of the magnetic shell number L and the pitch angle $\alpha$. The $\chi$ is found by a Monte Carlo-like method for a variety of tilt angles from 0° to 35°. The tilt angle is the angle between the earth's magnetic field and the earth-sun line. A weighting factor proportional to the fraction of the time that the neutrons are incident at each tilt angle is used to compute a time-averaged injection coefficient. A solar neutron spectrum and a mean atmospheric density, both averaged over the solar cycle, are used to find the contribution of solar neutrons to the equilibrium high-energy proton flux. This equilibrium SND injection proton flux is compared with that from cosmic-ray albedo neutron decay (CRAND) injection and with experiment. In addition, the relative proton injection rates for SND and CRAND are compared on the magnetic equator as a function of both L and energy. It was found that SND dominates over CRAND injection at higher L values and higher energies. (auth)

**17810** DIRECT DETECTION OF ASYMMETRIC INCREASES OF EXTRATERRESTRIAL RING CURRENT PROTON INTENSITIES IN THE OUTER RADIATION ZONE. Frank, L. A. (Univ. of Iowa, Iowa City). J. Geophys. Res.; 75: 1263-8(1 Mar 1970).

Measurements of the spatial distributions and temporal varia-

tions of the extraterrestrial "ring current" proton intensities near the magnetic equator during selected phases of two moderate magnetic storms on July 9 and September 8, 1966, provide direct evidence of asymmetric enhancement of these proton intensities deep in the outer radiation zone, during the early development of the latter magnetic storm. Increases of these low-energy proton ($5 \lesssim E \lesssim 50$ keV) intensities in the evening-midnight quadrant of the outer radiation zone on L shells ≈3.5 to 5.0 were accompanied by a substantial polar magnetic substorm observed during similar local times. However, no increases of proton intensities at levels above those typical of the "quiescent ring current" centered at $L \sim 6.5$, were yet observed near local noon, several hours later. Several implications that concern the origin and motions of this plasma during the early development phase of the magnetic storm are discussed. (auth)

**17811** OMNIDIRECTIONAL INTENSITY CONTOURS OF LOW-ENERGY PROTONS ($0.5 \leq E \leq 50$ keV) IN THE EARTH'S OUTER RADIATION ZONE AT THE MAGNETIC EQUATOR. Frank, L. A.; Owens, H. D. (Univ. of Iowa, Iowa City). J. Geophys. Res.; 75: 1269-78(1 Mar 1970).

Observations of low-energy proton intensities within seven selected energy bandpasses spanning the energy range $0.5 \leq E \leq 50$ keV are summarized in diagrams of L versus time for the period 10 June through 23 July 1966. These contours of omnidirectional, differential proton intensities were calculated via measurements of the directional, differential spectrums of the proton intensities with a sensitive electrostatic analyzer array borne on the earth satellite OGO 3 at mid- and low latitudes in the outer radiation zone and are normalized to a geomagnetic latitude 0° (magnetic equator). Diagrams of L versus time provide a compact, useful summary of these unique observations of proton intensities over L values ranging from ~3.0 to 12 and promote further insight into the morphological features of one of the most dynamically important components of magnetospheric plasma. (auth)

**17812** ELECTRON PRECIPITATION PULSATIONS. Coroniti, F. V.; Kennel, C. F. (Univ. of California, Los Angeles). J. Geophys. Res.; 75: 1279-89(1 Mar 1970).

When high-frequency wave turbulence is present, low-frequency micropulsations can strongly modulate the high-frequency wave amplitudes, leading to finite amplitude pulsations in the loss rate of energetic electrons from the magnetosphere (micropulsation amplitude is small). An extremely idealized model suggests that the precipitation modulation depends exponentially on the micropulsation amplitude, when the micropulsation period is less than the electron precipitation lifetime. (auth)

**17813** OBSERVATIONS OF THE AURORA IN THE FAR ULTRAVIOLET FROM OGO 4. Chubb, T. A.; Hicks, G. T. (Naval Research Lab., Washington, D. C.). J. Geophys. Res.; 75: 1290-1311(1 Mar 1970).

Observations of the aurora have been made from the OGO 4 spacecraft in the far ultraviolet. Auroral arcs were found to be easily detectable even in full sunlight, and the aurora was observed to be continuously present with little difference between southern and northern hemispheres. The morphology of the far ultraviolet aurora is quite similar to that of the visible aurora. The middle day aurora was observed to be about 40% as bright as the middle night aurora and to occur at about 8° higher invariant latitude. Minimum relative brightness seems to occur in late morning. The center of the auroral oval was generally observed to be dark. Lyman $\alpha$ rich arcs were frequently observed on evening crossings of the oval and were observed equatorward of arcs of normal color; in three morning crossings of the oval, Lyman $\alpha$ rich arcs were observed poleward of arcs of more normal color. At high Kp the auroral display brightened and moved equatorward. Displays with considerable stability in arc structure for periods of up to 5 hours were observed, whereas other displays showed significant change from orbit to orbit. Arcs were observed with maximum contrast relative to the dayglow in the 1350- to 1550-A band. (auth)

**17814** IONOSPHERIC AND MAGNETIC OBSERVATIONS DURING THE ANNULAR SOLAR ECLIPSE OF NOVEMBER 23, 1965. van der Laan, Jan E. (Stanford Research Inst., Menlo Park, Calif.). J. Geophys. Res.; 75: 1312-18(1 Mar 1970).

Vertical-incidence (VI) ionograms, magnetograms, and relative VI signal-amplitude (7-MHz) data were obtained in Bangkok, Thailand, during the annular solar eclipse on 23 November 1965. A maximum of 86% obscuration of the solar disk was observed at about 1007 local time (0307 GMT) in Bangkok, which was approximately 290 km from the center of the eclipse path. Marked changes in $F_2$-layer virtual height and considerable stratification of the F layer, including formation of an $F_{1.5}$ layer, were observed. Magnetograms indicate a large (approximately 25%) diminution in ionospheric current relative to normal solar daily ($S_q$) variations. (auth)

**17815** THE DAY-TO-DAY VARIABILITY OF THE EQUATORIAL ELECTROJET IN PERU. Burrows, K. (Goddard Space Flight Center, Greenbelt, Md.). J. Geophys. Res.; 75: 1319-23(1 Mar 1970).

By means of a semi-automatic procedure, scalings taken from the H records of a latitude spread of seven magnetometers, located close to the dip equator in Peru, have been used to investigate the variability of the electrojet on a day-to-day basis for the period from the December solstice to the equinox during a solar minimum. Large daily changes in intensity, position, and width are found, but no correlation between these quantities can be resolved. No systematic seasonal variations are found, but the records reveal a significant lunar modulation of the electrojet intensity. (auth)

**17816** BEHAVIOR OF HYDROXYL EMISSION DURING AURORA. Harrison, A. W. (Univ. of Calgary, Alberta). J. Geophys. Res.; 75: 1330-3(1 Mar 1970).

Analysis of auroral spectra (1.02 to 1.13 $\mu$) and photometric records of the O I (5577) auroral emission obtained during 6 hours of continuous IBC II-III aurora on November 1-2, 1968, leads to the conclusion that on this occasion the hydroxyl emission normally present in the near infrared night airglow spectrum was not significantly correlated with the O I (5577) brightness fluctuations. (auth)

**17817** OBSERVATION IN SITU OF AN AURORAL PULSATION. Parkinson, T. D. (Univ. of Pittsburgh); Zipf, E. C.; Dick, K. A. J. Geophys. Res.; 75: 1334-8(1 Mar 1970).

An auroral pulsation was observed by all instruments on board an Aerobee rocket that was launched into a diffuse IBC class I aurora above Fort Churchill, Canada. This event was also observed from the ground by a multichannel photometer that monitored the auroral activity within the field of view of the rocket. Data from the ground-based equipment and evidence from the rocket experiment indicate that the pulse was primarily a temporal fluctuation rather than the result of the lateral motion of the vehicle through the auroral form. The data suggest that the apparent downward propagation speed for the incoming electron flux pulse was only 5 km/sec. (auth)

**17818** PHYSICAL CONDITIONS IN THE BOW SHOCK OF THE EARTH'S MAGNETOSPHERE. Shen, Wen-Wu. Lawrence, Kan.; Univ. of Kansas (1969). 125p.

Thesis.

The interactions between the solar wind plasma and the terrestrial geomagnetic field create a sharp boundary, which is noted as the magnetosphere, to the Earth's magnetic field. Based on the hydromagnetic description of the solar wind, physical properties of the solar wind plasma and magnetic field in the bow shock, magnetosheath, and on the magnetosphere are investigated from the consideration of the magnetohydrodynamic interactions between the solar wind and the magnetosphere in the presence of an oblique interplanetary magnetic field. On the assumption of magnetohydrodynamic shock, the distribution of the pressure on the magnetosphere is obtained by integrating hydromagnetic equations from the bow shock to the magnetospheric boundary. The effect of an oblique magnetic field and the value of adiabatic exponent $\gamma$ in the solar wind are discussed. (Diss. Abstr.)

**17819** TOPSIDE OBSERVATION OF ELECTRON DENSITY VARIATIONS (G-CONDITION) AT TIMES OF LOW MAGNETIC ACTIVITY. Herzberg, L. (National Radio Propagation Lab., Ottawa); Nelms, G. L.; Dyson, P. L. Can. J. Phys.; 47: 2683-9(1 Dec 1969).

The so-called G-condition of the ionosphere (foF2 < foF1, with normal foF1) is investigated from the topside with the Alouette II satellite. In the absence of a severe magnetic disturbance, the condition is occasionally observed over a path length of the order of a thousand kilometers. In this case, one observes a characteristic development: in the F2 region at the levels below about 1000 km there is a systematic decrease of electron density to about one-half the original value, followed by a gradual increase to normal, and at the levels above about 1000 km there is a corresponding increase, followed by a decrease back to normal. This variation in electron density is accompanied, at levels below 2000 km, by significant increases in scale height. Cylindrical electrostatic probes carried on the satellite show, at the same time, increases in electron temperature. Possible interpretations of the observational data are discussed. (auth)

**17820** SPECTRUM OF THE AIRGLOW BETWEEN 4 AND 8 MICRONS. Bunn, F. E.; Gush, H. P. (Univ. of British Columbia, Vancouver). Can. J. Phys.; 48: 98-100(1 Jan 1970).

The airglow spectrum between 4 and 8 microns observed from an altitude of 90,000 ft contains only features due to thermal emission of stable atmospheric constituents. (auth)

**17821** MORPHOLOGY OF AURORAL ABSORPTION DURING SUBSTORMS. Jelly, Doris H. (National Radio Propagation Lab., Ottawa). Can. J. Phys.; 48: 335-45(1 Feb 1970).

Multistation riometer measurements of ionospheric radio-wave absorption have been used to infer the characteristics of the higher-energy component of electron precipitation during substorms. Two analyses are presented which deal separately with longitudinal and latitudinal variations. The first is based on data from four riometer stations located at $L \approx 5.2$ and at about 90° longitude intervals, and the second on a chain of five riometer stations spaced at about 3° intervals across the auroral zone. Previous work has shown that substorms detected at night are accompanied by daytime precipitation. In the present study, the average substorm absorption is found to have two broad maxima, one at night within 15 min of the absorption onset, and another during the morning about an hour after this onset. There is very little effect in the evening. From the latitude study, a transition is observed during the nighttime phase of substorms between the abrupt, irregular, intense absorption at higher latitudes and the smoother, less intense absorption at lower latitudes. This transition, designated as $\Lambda_a$, is observed at a median latitude of $\Lambda_a = 65° \pm 1.5°$. For the majority of a sample of 181 events selected from 1964 and 1967 records, the absorption was observed to start in the vicinity of $\Lambda_a$. With increased magnetic disturbance (measured by $K_p$), $\Lambda_a$ is observed to shift to lower latitudes. The $K_p$ variation is compared with that of energetic-particle boundaries. (auth)

**17822** ABSORPTION OF HYDROMAGNETIC WAVES IN THE IONOSPHERE. Abbas, M. (Ohio Univ., Athens). Can. J. Phys.; 48: 362-6(1 Feb 1970).

Absorption of hydromagnetic waves in the ionosphere propagated normal to the magnetic field is calculated at various frequencies and compared with the absorption for parallel propagation. Data corresponding to both daytime and nighttime ionospheres are used. Waves propagated normal to the magnetic field are highly absorbed through the daytime ionosphere at frequencies above a few Hz; the nighttime ionosphere, however, is virtually transparent to waves in the frequency range of $10^{-3}$ to 20 Hz. A comparison of the absorption processes for waves propagated parallel and normal to the magnetic field is made. (auth)

**17823** HYDROMAGNETIC WAVE INTERACTION WITH THE MAGNETOPAUSE AND THE BOW SHOCK. McKenzie, J. F. (European Space Research Inst., Rome). Planet. Space Sci.; 18: 1-23(Jan 1970).

The results of analyses of hydromagnetic reflection and refraction at a shear layer and at a shock are applied to situations representative of the magnetopause and the Earth's bow shock. The almost complete absence of magnetic fluctuations in the outer fringes of the magnetopause is explicable in terms of the magnetopause behaving like a near perfect reflector to the turbulent hydromagnetic waves in the magnetosheath. Therefore it seems unlikely that the turbulent sound wave refraction mechanism is very effective in producing a viscous-like interaction between the solar wind and the magnetosphere. For conditions typical of the solar wind and the magnetotail during quiet times the stability analysis given here indicates that the tail of the magnetopause is unlikely to undergo Kelvin–Helmholtz instability. However, during times when the solar wind blows harder than it usually does the distant tail of the magnetopause will exhibit not only instability but also greatly enhanced hydromagnetic wave transmission into the tail from the magnetosheath. It is noted that both longitudinal and transverse waves can be amplified on passage through a strong shock. Thus the amplification of the turbulent spectrum of hydromagnetic waves in the solar wind on passage through the Earth's bow shock may account for the (at least) order of magnitude increase of the noise spectrum in the magnetosheath over that in the unshocked solar wind. (auth) (UK)

**17824** MAGNETOSPHERIC PLASMAPAUSE AND THE ELECTRON DENSITY TROUGH AT THE ALOUETTE I ORBIT. Rycroft, M. J. (Univ. of Southampton, Eng.); Thomas, J. O. Planet. Space Sci.; 18: 65-80(Jan 1970).

The location of the magnetospheric plasmapause or "knee" and the position of the electron density minimum or "trough" at the orbit of the Alouette I satellite near 1000 km have been derived from whistler data and from topside ionograms respectively. A statistical study of the dependence of both knee and trough positions on the degree of magnetic disturbance and on local time during the Summer of 1963 reveals that, in general, within the statistical scatter, the geomagnetic field lines on which each occur are the same. During the local night, the equatorial radial distance to the center of the plasmapause is described by the relation: $R_p = 5.64 - (0.78 \pm 0.12)\sqrt{K_p}$ Earth radii, whereas the field line through the center of the electron density trough is best described by the equation: $L_T = 5.64 - (1.09 \pm 0.22)\sqrt{K_p}$. It is inferred that the plasmapause in the magnetosphere and the trough near the exospheric base are related phenomena, and that a sharp decrease of plasma density occurs beyond a particular field line, the position of which depends on local time and on the degree of geomagnetic activity. For magnetically quiet conditions ($K_p = 0$), this line of force corresponds to $L \simeq 5.6$ near midnight, whereas for moderate magnetic activity ($K_p = 3$) its L value is approximately 4. The radial distance at which this field line crosses the equatorial plane decreases at a rate of approximately 0.1 Earth radii/hr throughout the local night. The geomagnetic latitude at which the field line concerned reaches an altitude of 1000 km is approximately 57° at 02.00 LT for $K_p \simeq 3$, and decreases at a rate of $1.8° \pm 0.4°$ per unit increase of $K_p$. (auth) (UK)

**17825** EXOSPHERIC PLASMA DURING THE INTERNATIONAL YEARS OF THE QUIET SUN. Thomas, J. O. (Imperial Coll. of Science and Tech., London); Rycroft, M. J. Planet. Space Sci.; 18: 41-63(Jan 1970).

Although a great deal of information is now available about the distribution of electrons in the topside ionosphere, much of the published data refer to a single altitude, namely that of the vehicle carrying the experimental payload. It is well known that topside soundings provide accurate routine measurements of the electron density over a wide range of altitudes simultaneously. Information is given about a number of surveys made as an extensive program of analysis carried out in the Space Sciences Division of the NASA Ames Research Center, the detailed results of which, presented in a series of NASA Special Publications, provide data on the overall morphology of the topside ionosphere during, and close to, the International Years of the Quiet Sun. The importance is emphasized of the diurnal and latitudinal variations of plasma scale height for the interpretation of the data in terms of the physics of the topside, and as an indication of geomagnetic control of the upper F-region. Attention is mainly concentrated on data derived for the highest altitudes possible (near 1000 km), away from the widely-discussed problems of the F-region peak (Rishbeth, 1968). The scale height distribution can be understood in terms of diffusive equilibrium theory, using which the mean ionic mass of the plasma can be derived. (auth) (UK)

**17826** DISPERSION ANALYSIS OF INTERPLANETARY SCINTILLATION. Golley, Malcolm G.; Dennison, Paul A. (Univ. of Adelaide). Planet. Space Sci.; 18: 95-101(Jan 1970).

By the application of dispersion analysis to records of interplanetary scintillation taken from a triangular arrangement of receivers, it is found that the velocity of drift of the diffraction pattern increases with temporal frequency of different Fourier components of the pattern. Part of the observed dispersion is believed to arise as a result of integration along an extended line of sight but the possibility exists of a contribution from the interplanetary medium itself. Such an effect, if confirmed by further observations, would imply the existence of structures in the solar wind travelling at enhanced velocity relative to the mean flow. (auth) (UK)

**17827** MODEL OF THE POLAR ION EXOSPHERE. Lemaire, J.; Scherer, M. (Belgian Inst. for Space Aeronomy, Brussels). Planet. Space Sci.; 18: 103-20(Jan 1970).

A model of a polar ion-exosphere in which the geomagnetic field lines are open is developed. The electrostatic field in this region has been calculated by taking into account two fundamental conditions: (1) quasi-neutrality has to be satisfied everywhere in the exosphere; (2) escape fluxes of electrons and ions have to be equal. The density distributions are calculated for different evaporative models in the case of two ($O^+$ and e) and three ($O^+$, $H^+$ and e) constituents. In addition, the mean velocity, pressure and temperature distributions of the several constituents are derived. (auth) (UK)

**17828** TIDAL WINDS AND THE $S_q$ CURRENT SYSTEMS. Stening, R. J. (Univ. of Queensland, St. Lucia, Australia). Planet. Space Sci.; 18: 121-2(Jan 1970).

Recent measurements by Balsey (1969) of electron drift velocities in the equatorial electrojet, which presented new data on the times of current reversal in the electrojet, were used in studying the role of semi-diurnal and diurnal winds in driving the $S_q$ current system. The calculations described here were performed using an equivalent circuit to represent the ionosphere and solving the equations of the circuit by an iterative method on a computer. The two tidal modes most likely to be effective in driving the $S_q$

system are the symmetrical diurnal '1,-2' mode and the semi-diurnal '2,2' mode. The calculations were compared with previous data. (UK)

17829 TROUGH OF ELECTRON DENSITY OCCURRING AT MIDDLE LATITUDES IN WINTER. Lieger, P. F. (Univ., Graz). Z. Geophys.; 35: 581-7(Dec 1969). (In German).

At many registrations of the Faraday-fading of signals of the satellite Explorer 22 taken by day at Graz (47,1°N, 15.5°E) striking fluctuations in the length of the fadings period were found. It is shown, that these fluctuations have their origin in a trough of electron-content at about 37° to 44° northern latitude. This trough—appearing during day—shows a characteristic seasonal variation. It can be observed predominantly during the winter period, and then most frequently in the morning hours. It is supposed that this above mentioned trough is a remainder of the main trough of ionisation found during the night. That would explain the seasonal and temporal occurrence, because during the morning hours of the winter-period the F2-layer is highly influenced by the conditions during the preceeding night. (auth)

17830 DUCTING OF ACOUSTIC–GRAVITY WAVES IN THE ATMOSPHERE WITH SPATIALLY PERIODIC WIND SHEARS. Liu, C. H. (Univ. of Illinois, Urbana). J. Geophys. Res.; 75: 1339-41(1 Mar 1970).

A mechanism for horizontal ducting of acoustic gravity waves in the atmosphere is studied. One assumes a background horizontal wind with a periodic vertical shear of the form $v_0 \sin K_1 z$. This wind may interact with the acoustic-gravity wave to cause horizontal ducting of the wave. The ducting condition is derived. Trapping depth for a typical atmosphere is computed. (auth)

17831 OBSERVATIONS OF 8-AMU/UNIT CHARGE ION CYCLOTRON WHISTLERS. Gurnett, Donald A.; Rodriguez, Paul (Univ. of Iowa, Iowa City). J. Geophys. Res.; 75: 1342-4(1 Mar 1970).

A new ion cyclotron whistler associated with ions having a mass to charge ratio of 8-amu/unit charge has been found in the Injun-5 satellite vlf radio noise data. Some of the properties of this whistler are discussed. (M.O.W.)

17832 HYDROGEN ATOM PARTICIPATION IN D REGION ION CHEMISTRY. Burke, Rudolf R. (AeroChem Research Labs., Inc., Princeton, N. J.). J. Geophys. Res.; 75: 1345-7 (1 Mar 1970).

A mechanism is proposed for hydrogen precipitation in the D region. The proposed mechanism is $P^+ \cdot nH_2O + H \rightarrow H_3O^+ \cdot (n-1)H_2O + P$, where $P = NO, O_2$. These reactions are discussed. (M.O.W.)

17833 GEOCORONA AND ITS IMPORTANCE FOR THE UPPER ATMOSPHERE. Rossbach, A. (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen, Ger.). Z. Geophys.; 35: 557-64(Dec 1969). (In German).

The geocorona is a hydrogen atmosphere beginning at a height of 80 km and extending to some 1000 km in the interplanetary space. The main part of the upper atmospheric hydrogen has its origin in the photodissociation of water vapor and methane on the day side at the mesopause level. The geocoronal glow is excited by resonant scattering of solar Lyman-α-radiation by hydrogen atoms. Models for the hydrogen distribution are described. Optical measurements of the scattering intensity show distinct differences in the vertical density. The properties for Ly-α-scattering in the regions of variable optical thickness are discussed. Measurements of the zenith-nadir-differences in the medium region of the geocorona with the German satellite DIAL should allow a better knowledge of the excitation conditions. (auth)

17834 ENERGY SPECTRA OF AURORAL ZONE PARTICLES. Chase, Lee MacArthur. Berkeley, Calif.; Univ. of California (1969). 105p.

Thesis.

Three Nike–Tomahawk sounding rockets were launched from Fort Churchill, Manitoba, Canada during February and March of 1968. The rockets were instrumented to measure energy spectra of electrons and protons between 0.5 and 20 keV energy with 10% resolution. Two of the rockets were launched into auroral breakups near local midnight. The other rocket was launched into a 2.5 db riometer absorption event at local noon. Results show that electron fluxes in the auroral zone resemble electron fluxes in plasma sheet, both in the shape of energy spectra and in the magnitude of flux, indicating that the plasma sheet may be the source of auroral-zone electrons. The proton fluxes in these two regions are quite different. Thus the plasma sheet probably is not the source of auroral-zone protons. Time variations of 1 keV electrons and protons were found to be coherent, indicating similar precipitation mechanisms for these two types of particles. The source of 1 keV electrons was found to have a wider spatial extent than the source of 10 keV electrons. During auroral breakup electron precipitation was found to be isotropic over the upper hemisphere while the protons were anisotropic, with more flux at 90° than at 0°. (Diss. Abstr.)

17835 CALCULATED DOSE RATES IN JUPITER'S VAN ALLEN BELTS. Haffner, J. W. (North American Rockwell Corp., Downey, Calif.). AIAA (Amer. Inst. Aeronaut. Astronaut.) J.; 7: 2305-11(Dec 1969).

A series of particle flux and dose rate calculations have been carried out based upon the assumption that the decimetric rf noise emanating from the vicinity of Jupiter is synchrotron radiation from electrons trapped in a dipole magnetic field. Based upon plasma stability considerations and observations in the Earth's Van Allen belts, a relationship between the surface equatorial magnetic field strength ($H_0$), the spatial electron density (N) and the effective inner radius (a) of the belts was obtained. Three self-consistent belt models were considered ($H_0$ = 2, 5, and 15 oe) and the point tissue dose rates behind 0.1–10 g/cm² aluminum were calculated. Based upon these assumptions, these dose rates were approximately constant (± a factor of 3) out to ~15 Jupiter radii, whether the Jovian belts consisted of a large number of low-energy particles (small $H_0$) or a smaller number of higher-energy particles (large $H_0$). (auth)

17836 VERTICAL MOVEMENTS IN THE D REGION OF THE IONOSPHERE. Nestorov, Georgi. Izv. Geofiz. Inst., Bulg. Akad. Nauk; 15: 67-93(1969).

Data are given on the following topics: (1) vertical movement of the discreet ionization levels under daytime conditions and quiet ionosphere, (2) vertical movements at disturbed ionosphere, (3) electron transport, (4) anomalies in the D region connected with the vertical movement of the plasma, and (5) increase of the total quantity of electrons at D-region movement. (M.O.W.)

17837 THE ELECTRON DENSITY DISTRIBUTIONS IN THE D REGION DURING THE NIGHT AND PRE-SUNRISE PERIOD. Thomas, L.; Harrison, M. D. (Radio and Space Research Station, Slough, Eng.). J. Atmos. Terrest. Phys.; 32: 1-14(Jan 1970).

Experimental measurements of reflection and conversion coefficients over a range of frequencies from 16 to 71 kHz are used to deduce electron density distributions for nighttime and the pre-sunrise period. A full-wave integration method which takes account of the energy dependence of the electron collision frequency is used to compute propagation parameters for waves reflected from a postulated model of electron density. These computations are made for azimuth and incident angles relevant to the paths for which experimental data are available, the appropriate angles of incidence being found using a stationary phase technique. The electron density distribution is then suitably modified until the computed values agree with the experimental measurements. In this way the electron density distributions representative of night-time and subsequent times up until ground sunrise are deduced for Summer, high solar activity conditions at middle latitudes. The electron density distribution at nighttime shows a ledge of ionization of density about 100 cm$^{-3}$ situated between 82 and 90 km, and a sharp gradient near 90 km. The pre-sunrise changes in electron density first occur near 80 km and the electron densities at lower heights increase progressively as the solar zenith angle is reduced. The deduced electron densities are compared with the results obtained by direct measurements. (auth) (UK)

17838 D-REGION WINTER ANOMALY AND TRANSPORT NEAR THE MESOPAUSE. Christie, A. D. (Meteorological Service of Canada, Toronto). J. Atmos. Terrest. Phys.; 32: 35-56(Jan 1970).

Currently available information on electron density distributions in relation to both day to day, and seasonal variation in radiowave absorption in the D region is interpreted in terms of transport processes near the mesopause. Many common features in the thermal, flow and radiative temperature change distributions in the vicinity of the tropopause in midlatitudes, and the winter mesopause in low latitudes are discussed, and it is inferred that transport processes may be similar in the two regions. The fairly simple relationship between electron densities and nitric oxide concentration in the D-region is outlined, and the transport of nitric oxide in large scale wave systems discussed. The properties of nitric oxide in the lower thermosphere and upper mesophere are discussed and shown to be similar in many respects to those of ozone in the lower stratosphere. The day to day variations in electron densities in the D-region are interpreted by analogy with the more familiar tracer transports near and through the tropopause. The seasonal variations are then discussed from the viewpoint of the meteorological energetics of the D-region, and the balance equation for nitric oxide. A

final note advocates the use of the radiowave partial reflection technique, on a network basis, to study the synoptic structure and energetics of the region near the mesopause. (auth) (UK)

**17839** INTERPRETATION OF TRANSEQUATORIAL VLF SUNRISE OBSERVATIONS. Lynn, K. J. W. (Univ. of Queensland, Brisbane). J. Atmos. Terrest. Phys.; 32: 57-68(Jan 1970).

Further analysis and interpretation of transequatorial multisite vlf records has established a solar zenith angle of $\chi = 94 \pm 1°$ for the mid point of the sunrise ionospheric height discontinuity in middle latitudes, with consequent agreement between theory and the experimental value of arg $(S_{11}/S_{21}) = -5 \pm 8°$. The positions of magnetic-latitude-dependent parameters were recomputed with the new sunrise line definition and are displaced 5° magnetic to the north of their previous locations. A simple latitude symmetric variation of differential phase velocity and relative starting phase of the two major propagating modes within ±10° of the magnetic equator is shown to account for the displacement of the maximum D′ values to the south of the magnetic equator. This model explains the clustering of data points in terms of changes in the velocity of the transequatorial interference pattern when the sunrise line is within the equatorial region. (auth) (UK)

**17840** OSCILLATIONS OF ELECTROSTATICALLY TRAPPED PARTICLES. Liu, V. C.; Hung, R. J. (Univ. of Michigan, Ann Arbor). J. Atmos. Terrest. Phys.; 32: 69-82(Jan 1970).

A kinetic theory of longitudinal ionic oscillations is presented which pertains to an earlier hypothesis that low frequency plasma oscillations monitored in the wake of Ariel I Satellite are due to ions trapped in the potential trough behind a moving satellite. The treatment is one-dimensional. A self-consistent potential distribution in the trough is obtained from a linearized analysis, suitable for a potential trough of small depth. Dispersion relation of the plasma oscillations for the trapped particles are obtained. The conditions for instability of the oscillation are given. The present analysis further confirms the earlier hypothesis as stated above. (auth) (UK)

**17841** THE VARIATIONAL METHOD OF RAY PATH CALCULATION IN AN ANISOTROPIC, GENERALLY INHOMOGENEOUS IONOSPHERE. Smilauer, J. (Geophysical Inst., Prague). J. Atmos. Terrest. Phys.; 32: 83-96(Jan 1970).

The use of the variational method for searching the ray path of a high-frequency electromagnetic wave between two fixed points is proposed, the knowledge of which is required, e.g., in ionospheric research using measurements on radio signals from Earth's satellites. The problem was solved for the case of a lossless ionospheric plasma with electron density gradient in arbitrary direction, and for the dipole geomagnetic field. To solve the problem, a curvilinear coordinate system was used in which the vector of the geomagnetic field intensity lies in the (xy) plane at every point of the path. Analysis of this system was made showing that, in most cases, it can be considered as nearly Cartesian. The ray path can then be expressed with sufficient accuracy by two second-order differential equations that are solved by the Galerkin's variational method by means of a system of suitable functions. The form of the functions was derived and their properties are shown by which a quickly converging solution is guaranteed. (auth) (UK)

**17842** SOME PHASE-HEIGHT MEASUREMENTS ON THE E REGION. Butcher, E. C. (Univ. of Exeter, Eng.). J. Atmos. Terrest. Phys.; 32: 97-112(Jan 1970).

The variation in phase path of a stable continuous wave transmission that during the daytime is reflected from the E region, was monitored for several months during the period 1964–1965. From these observations, diurnal variations in the phase height of the E region were deduced. These results show that during the initial formation of the layer, the phase height varied approximately as a Chapman layer with an average scale height of 6.94 km. However, during the central part of the day, deviations from a Chapman layer were observed which were consistent with the assumption that near the time of the maximum east–west $S_q$-current flow, the ionization density below the reflection level increased due to electromagnetic drift associated with this current flow. Nighttime results were characterized by the regular occurrence of an $E_s$ layer, which appeared approximately 1 hr after ground sunset and descended slowly for 0.5 to 2 hr before disappearing. From such an event an estimate of the recombination coefficient for the layer was made, on the assumption that the layer decayed as an $\alpha$-Chapman layer. Comparison of phase height variations for two different paths indicated the large extent of some of these nighttime $E_s$ layers. (auth) (UK)

**17843** NORTH–SOUTH ASYMMETRY OF IONOSPHERIC STORMS: DEPENDENCE ON LONGITUDE AND SEASON. Rajaram, Girija; Rastogi, R. G. (Physical Research Lab., Ahmedabad, India). J. Atmos. Terrest. Phys.; 32: 113-18(Jan 1970).

The study of ionospheric storms at pairs of north and south mid-latitude stations in different longitude zones, individually for each season, has shown asymmetry in their behavior, most significantly in the Pacific zone, to some extent in the Asian and American zones. The decrease of $f_0F2$ which is found to occur during geomagnetic storms in Summer months is conspicuously absent at Rarotonga. This suggests that ionospheric storm variations are greatly affected by horizontal and vertical movements of ionization, which are controlled by the asymmetric magnetic field of the Earth. (auth) (UK)

**17844** HORIZONTAL GRADIENTS IN AURORAL RADIO ABSORPTION AND THEIR EFFECT ON THE HEIGHTS DETERMINED BY MULTIFREQUENCY RIOMETRY. Hargreaves, J. K. (Inst. for Earth Sciences, Boulder, Colo.). J. Atmos. Terrest. Phys.; 32: 123-6(Jan 1970).

Data are presented on the large-scale horizontal gradients in auroral radio absorption, and their effect on the measurement of absorption height by multifrequency riometry is assessed. It is deduced that the exponent "n", expressing the dependence of absorption on radio frequency, is typically depressed by 0.05 to 0.15 (according to circumstances), and that quoted heights are too low by at least several kilometers. (auth) (UK)

**17845** SOME RESULTS OF GEOPHYSICAL INVESTIGATIONS AT VOSTOK STATION. Driatskii, V. M.; Zhigalov, L. N. (Arctic and Antarctic Scientific Research Inst., Antarctica). Sov. Antarct. Exped. Inform. Bull. (Engl. Transl.); 7: 110-15(Dec 1969).

At Vostok Station near the south geomagnetic pole, numerous geophysical observations were carried out for the study of the characteristics of injection of solar corpuscular streams into the Earth's atmosphere at high latitudes. The magnetic lines of force in the polar cap are blown by the solar wind in the antisolar direction and form the so-called tail of the magnetosphere. How the solar particle fluxes responsible for geophysical phenomena penetrate into the Earth's atmosphere in two possible ways is discussed (from the tail of the magnetosphere into the night side and through neutral points into the day side). Auroral radio-wave absorption is extremely rare at Vostok Station. Fluxes of electrons of energy E > 40 keV, responsible for the anomalous ionization of the D layer and for auroral absorption in the auroral zone, do not usually penetrate into the region of the geomagnetic pole. The behavior of regular ionospheric layers at Vostok Station during daylight is nearly the same at middle latitudes. At high geomagnetic latitudes and particularly at Vostok Station most of the auroras are observed at a height of about 150 km or higher, indicating the low energy of particles (several keV) responsible for auroras. These particles cannot penetrate to the level of the current layer and cause geomagnetic disturbances, or penetrate to the D layer and cause radio-wave absorption. Polar-cap absorption (PCA) observations are described. The general pattern of PCA variation characterizes the variation in the intensity of the proton flux. Absorption is lower by a factor of 4 to 6 at night than during the daytime, i.e., so-called solar control is in effect. This is attributable to the different ratio between the effect of electron attachment to neutral atoms and molecular gases and photodetachment resulting from the effect of solar radiation on negative ions. (BBB)

**17846** INTERACTION OF AURORAL ELECTRONS WITH THE ATMOSPHERE. Chappell, Charles Richard. Houston, Tex.; Rice Univ. (1969). 150p.

Thesis.

A comparison was made between experimental measurements of backscattered auroral electrons and a theoretical calculation using a diffusion equation solution which included angular scattering, energy loss, and a converging magnetic field. These comparisons were made for several altitudes in the 300- to 794-km range, for energies of 1 to 20 keV, and for pitch angles of 20 to 70° and 110 to 160°. This detailed treatment of backscatter shows the dependence of the "reflection coefficient" on the energy, the pitch angle, and the shape of the energy spectrum of the incident particles and displays the possibility of "anomalously" high reflection coefficients. The comparison of theory and experiment shows that Coulomb scattering is not the only process that occurs and indicates the possible presence of atmospheric heating, parallel electric fields, and plasma-wave instabilities. No evidence is found for diffusion of pitch angle into the loss cone or loss-cone alteration by the auroral electrojet. (Diss. Abstr.)

**17847** SOURCES OF THE LYMAN-$\alpha$ EMISSION IN THE NIGHT SKY. Ingham, M. F. (Dept. of Astrophysics, Oxford). Mon. Notic. Roy. Atron. Soc.; 145: 401-4(1969).

Observations of Lyman-$\alpha$ in the night sky were made with a

Skylark rocket and indicate both a terrestrial and a galactic source for the emission. (auth) (UK)

**17848** SOLAR COSMIC-RAY IONIZATION IN THE LOW IONOSPHERE. Velinov, P. (Geophysical Inst., Sofia). J. Atmos. Terrest. Phys.; 32: 139-47(Feb 1970).

The enhanced electron production rate q(h) produced by solar cosmic rays (CR) in the lower ionosphere is theoretically considered. Formulas are deduced for q(h) of relativistic and low-energetic solar CR (polar cap absorption event). Expressions are obtained at $C_\delta \cos_\delta \theta$ angular distribution of the penetrating particles, from which formulas are derived for fully anisotropic ($\beta \to \infty$), anisotropic and isotropic ($\beta = 0$) distributions on the upper hemisphere. Besides the influence of the parameters of solar CR (spectrum, composition: p, $\alpha$, L, M, H, VH—nuclei) and Earth environment on q(h) is investigated. (auth) (UK)

**17849** SIMULTANEOUS FORWARD-SCATTER, RIOMETER, AND BREMSSTRAHLUNG OBSERVATIONS OF A DAYTIME ELECTRON PRECIPITATION EVENT IN THE AURORAL ZONE. Bailey, D. K. (ESSA Research Labs., Boulder, Colo); Brown, R. R.; Rees, M. H. J. Atmos. Terrest. Phys.; 32: 149-69(Feb 1970).

Ionospheric scatter propagation and absorption during an energetic electron precipitation event during daylight in the auroral zone are examined, using bremsstrahlung observations at balloon altitude to compute the precipitating electron flux. The electron spectrum responsible for the event is described as the sum of two exponential spectra, one soft (characteristic energy $E_0 = 9$ keV) and the other hard ($E_0 = 40$ keV). Analysis of the random and systematic errors of the observations places the effective scattering height at $75 \pm 2$ km. (auth) (UK)

**17850** ELECTRON DENSITY VARIATION OBSERVED IN THE E LAYER BELOW AN ARTIFICIAL BARIUM CLOUD. Stoffregen, W. (Research Inst. of Swedish National Defense, Uppsala). J. Atmos. Terrest. Phys.; 32: 171-7(Feb 1970).

Observations are reported that seem to verify that there exists a connection in terms of an electron transport between an artificial barium ion cloud and the E-layer below, the E-down range. The observed increase of 5577 and 4278 Å emission in the E-down range is explained as a local change of the electron density. The observations are interesting so far as a coupling between the barium cloud and the lower ionosphere is important for the understanding of the dynamics of the ion cloud and also has been regarded as a contributory fact to explain the appearance of field-aligned ray-like structure of the ionized Ba cloud. (auth) (UK)

**17851** AN IMPROVEMENT IN THE CLOSELY SPACED FREQUENCIES METHOD OF DEDUCING IONOSPHERIC ELECTRON CONTENT FROM FARADAY ROTATION MEASUREMENTS. Crooker, Nancy Uss (Univ. of California, Los Angeles). J. Atmos. Terrest. Phys.; 32: 179-85(Feb 1970).

There is a certain amount of ambiguity in the closely-spaced-frequencies method of deducing ionospheric electron content. This ambiguity arises from a lack of knowledge of the difference in the absolute amounts of Faraday rotation undergone by the planes of polarization of the two transmissions involved. A method is outlined which, in most cases, eliminates this ambiguity. Its advantages over alternate methods are discussed. (auth) (UK)

**17852** SATURATION AND FOCUSING EFFECTS IN RADIO-STAR AND SATELLITE SCINTILLATIONS. Singleton, D. G. (Weapons Research Establishment, Salisbury, Australia). J. Atmos. Terrest. Phys.; 32: 187-208(Feb 1970).

The diffraction and refraction theories of radio-star and satellite scintillations are reexamined and successfully reconciled to produce a composite result. This result gives new emphasis to the importance of focusing and saturation effects in scintillation studies. The result is displayed as contours of equal scintillation index on a plot of the distance parameter $\lambda z/r_f^2$ vs the rms phase deviation produced by the irregularities $\phi_0$. An approximate expression for the scintillation index, previously considered to be valid only for $\phi_0 < 1$ Rad, is shown to have wider application. In terms of this approximation, connections between a number of variables, which determine whether or not irregularities fall into the saturation and focusing regimes, are examined. These variables include electron density increment in the irregularities, their size and shape, azimuth and topocentric and magnetic zenith angles of the direction of propagation, observing frequency and geomagnetic latitude of the point of observation. As the result of these findings, possible explanations are put forward for a number of outstanding problems in scintillation studies. (auth) (UK)

**17853** SPREAD-F ON IONOGRAMS. King, G. A. M. (Geophysical Observatory, Christchurch, New Zealand). J. Atmos. Terrest. Phys.; 32: 209-21(Feb 1970).

Spread-F echoes are not due to partial reflection from small irregularities. Rather they are due to total reflection from large tilted surfaces of ionization. The geometry of these surfaces is examined using ionograms and airglow observations, together with Australian experiments reported in the literature. Except at very low latitudes, the surfaces are not generally field-aligned. When looking for causes of spread-F it is more rewarding to study range-spreading than frequency spreading. The paper presents a hypothesis for the generation of range spreading. (auth) (UK)

**17854** OBTAINING ELECTRON-DENSITY PROFILES OF PLANETARY IONOSPHERES. Kak, Avinash C. (Indian Inst. of Tech., Delhi). J. Atmos. Terrest. Phys.; 32: 233-6(Feb 1970).

Integral methods involving analytical solutions of obtaining electron-density profile of a stationary plasma, such as the Earth's ionosphere, from ionosonde records is extended to the case when the mass of plasma may be in motion such as in the exploration of planetary ionospheres and interplanetary gases. It has been shown that in the reference frame of an observer moving at a uniform velocity V, which is nonrelativistic, relative to the ionosphere, the formula for the determination of electron density is essentially the same as that for an observer stationary with respect to the ionosphere. However, the true-height integral undergoes considerable change and the correction can be large even for small V depending upon the duration of one cycle of measurement. (auth) (UK)

**17855** RADAR MEASUREMENTS OF THE MAGNETIC DIP IN THE E REGION. Watkins, C. D. (Royal Radar Establishment, Malvern, Eng.). J. Atmos. Terrest. Phys.; 32: 247-50(Feb 1970).

Radar measurements of ionization aligned along the Earth's magnetic field were used to obtain values of the magnetic dip angle in the E region. The results are compared with dip angles deduced from surface values, and with those given by a spherical harmonic model. (auth) (UK)

**17856** LUNAR INFLUENCE ON RADIO-AURORA. Forsyth, P. A. (Univ. of Western Ontario, London). J. Atmos. Terrest. Phys.; 32: 251-5(Feb 1970).

A series of radio-auroral observations extending over an 11-yr period are analyzed in an effort to detect the 29.5-day lunar period. While such a periodicity is present in the data it appears to arise as a result of the chance interaction of other well-known periodicities and not as a result of an interaction between the Moon and the magnetosphere. (auth) (UK)

**17857** COMPARISON OF ABSORPTION MEASURED BY RIOMETER AND BY IONOSONDE AT HIGH LATITUDES. Bell, C. D.; Morozumi, H. M. (General Electric Co., Syracuse, N. Y.). J. Atmos. Terrest. Phys.; 32: 257-60(Feb 1970).

Simultaneous observation made by riometer and vertical incidence sounder at Byrd Station, Antarctica in June 1963 indicate that absorption events occurring around magnetic midnight as determined by the riometer may be actually due to cosmic noise scattering by auroral sporadic-E rather than absorption. (auth) (UK)

**17858** THE 2- TO 0.1-Hz POLAR-CAP MICROPULSATION ACTIVITY. Heacock, R. R. (Univ. of Alaska, College); Hessler, V. P.; Olesen, Jens K. J. Atmos. Terrest. Phys.; 32: 129-38 (Feb 1970).

Magnetic field micropulsations, T = 0.2 to 500 sec, were recorded at Kanak, Greenland, for several years, simultaneously with micropulsation recordings taken at sites in Alaska and Finland. Some characteristics of short-period micropulsation activity at the pole station are described and compared to activity at auroral-zone sites. A strong seasonal variation in periodically-structured Pc 1 reception is found at Kanak and is attributed to a seasonal variation in propagation conditions in the polar cap F-layer horizontal waveguide. Unstructured Pc 1–2 activity was found to be especially prominent within the polar cap. (auth) (UK)

## Low-Temperature Physics

*Refer also to abstracts 16545, 16750, 16763, 17725, 18040, and 18097.*

**17859** ANALYSIS AND A MEASUREMENT OF AC POWER LOSS OF SUPERCONDUCTING WIRES. Sugawara, M. (Yokohama Univ., Japan). Denki Gakkai Zasshi; 89-5: 940-8(May 1969). (In Japanese).

AC power loss in the superconducting wires of type II was measured and quantitatively analyzed. Superconducting wires of Nb,

Nb–25% Zr and Nb–40% Zr–10% Ti, each 0.25 mm in diameter, were used in the measurement. The configuration of the wire specimens was simplified as much as possible to make the analysis easy. The voltage waveform induced by the time variation of magnetic flux density in the superconducting wire was observed on an oscilloscope. The voltage wave induced in the measuring circuit, 90° out of phase, was compensated by adjusting a mutual inductance inserted in the circuit. The calculation was made for two models, the Bean model, in which current density $|i|$ is constant in the region penetrated by the magnetic flux, and the Kim model, in which $|i \times B|$ is constant. For Nb–Zr and Nb wires, the measured values were consistent with the Kim model, while for Nb–Zr–Ti wire, result was consistent with the Bean model. The measured critical current for Nb–Zr wire was in agreement with the calculation. (NSA of Japan)

**17860** POSSIBILITY OF THE EXISTENCE OF SUPERCONDUCTORS WITH TWO CRITICAL POINTS. Kobelev, L. Ya. (Ural State Univ., Sverdlovsk, USSR). Fiz. Metal. Metalloved.; 28: 953-4(Nov 1969). (In Russian).

An assumption that Cooper's pairs in a superconductor act as elementary excitations, with dimensions described by the mean radius of the pair and the presence of interactions of repulsion D(x) (where x is the distance between the centers of gravity of the pair) make it possible to assume the existence of λ condensation, which can be described within the approximation of the theory of λ condensation in Bose system. (R.V.J.)

**17861** PECULIARITY OF SUPERCONDUCTING MODIFICATION OF BISMUTH. Lazarev, B. G.; Semenenko, E. E.; Sudovtsov, A. I. (Physical-Technical Inst., Kharkov). Fiz. Metal. Metalloved.; 28: 954-5(Nov 1969). (In Russian).

Data are given on properties of superconducting layers of bismuth produced by condensation of its vapor on glass backing cooled by liquid helium. (R.V.J.)

**17862** THEORY OF FLUX JUMPS IN RODS OF NON IDEAL TYPE-II SUPERCONDUCTORS. Takeo, Masakatsu; Yasuno, Takeshi; (and others) (Kyushu Univ., Fukuoka). Kyusnu Daigaku Kogaku Shuho; 42: 626-35(Aug 1969). (In Japanese).

The theory of flux jump in circular rods of nonideal type-II superconductor is developed and the result compared with the former analysis for plates. The phenomenological equations of motion are developed, and the density loss calculated. The loss due to viscous drag is neglected. Only the pinning force is taken into account. Some criteria for the occurrence of flux jump are given for the region of initial magnetization. The uniform temperature rise in the superconductor is assumed, and the equation for heat conduction is simplified, using the coefficient of heat transfer to ambient liquid, He. Comparison with the analysis for plates shows that, for a small external magnetic field, the plate approximation is sufficiently valid for rods. The range of magnetic field intensity in which the plate approximation is possible is shown. When the field exceeds this range, several features characteristic for circular rods appear. (NSA of Japan)

**17863** LOSSES IN SUPERCONDUCTING MAGNETS. Irie, Fujio; Yamafukji, Kaoru; (and others) (Kyushu Univ., Fukuoka). Denki Gakkai Zasshi; 89-9: 1709-18(Sep 1969). (In Japanese).

The loss in superconducting magnets due to the pinning force on magnetic flux was calculated. The mean density of the pinning force was given as $\alpha B\gamma$ with $\alpha$ and $\gamma$ as the inherent parameters of material. The equation of motion for magnetic flux density B was written down. By integration, the loss, the accumulation, and the input energy in a plate superconductor were calculated when the magnetic field parallel to the plate changed slowly. Similarly, the loss in the magnetization of superconducting solenoid was calculated. The flux density distribution in the superconducting solenoid for initial current increase, for current decrease, and for second current increase, was calculated, and the loss in each process was numerically determined. Comparison of the calculated value with the measurement for Nb–25% Zr wire was shown. By proper choice of parameters, good agreement was obtained. Application to a superconducting energy accumulator was discussed. (NSA of Japan)

**17864** THEORY OF THE RESISTIVE STATE OF EXTREMELY INHOMOGENEOUS TYPE II SUPERCONDUCTORS AND THE ELECTRON BAND MODEL. Takacs, S. (Inst. of Electrical Engineering, Bratislava). Czech. J. Phys.; 20: 21-31(1970).

An appropriate model for calculation of losses and induced voltages in extremely inhomogeneous type-II superconductors is discussed. For known magnetic-field dependence of the energy gap, also the field dependence of the critical current can be calculated. (auth)

**17865** CRITERION FOR THE STABILITY OF COMPOSITE SUPERCONDUCTORS. Ihara, S.; Kaiho, K. (Electrotechnical Lab., Tokyo). Denki Gakkai Zasshi; 89-6: 1097-1106(Jun 1969). (In Japanese).

The stability of a composite superconductor is discussed. The superconductor embedded in copper was examined, using experimental data obtained thus far. A criterion of stability was given by setting the propagation velocity of the normal phase which appears in the superconductor as negative. This was expressed approximately as $I^2\rho_n/A_n < \ln K_n (T_t - T_s)$. The left side of this inequality is the heat generation per unit length in stabilizing copper when the total current I is flowing in it, and the right side is the heat transferred to liquid He when the superconductor is at the transition temperature $T_t$. This condition coincides with that given by Stekly. Effect of the magnetic field on $\rho_n$, the resistivity of copper, and on $T_t$, complicated nature of heat transfer, etc., are discussed with available experimental data. It was found that the maximum average current density for composite wire is obtained when the cross-sectional ratio of the superconductor is ⅓ of the total cross section. (NSA of Japan)

**17866** THEORY OF QUANTUM FLUIDS. Feenberg, Eugene. Pure and Applied Physics. Volume 31. A Series of Monographs and Textbooks. New York; Academic Press Inc. (1969). 276p. $14.00.

An elementary treatment is presented, in a context of difficult problems, of the theory of uniform quantum liquids. Emphasis is placed on the microscopic description of liquid $^3$He and $^4$He in the physical density range using simple but basically realistic forms of the potential function between pairs of neutral atoms. Material on the radial distribution function and the three-particle distribution function, and a discussion of the problem of the charged boson system at high densities is included. Other topics considered include the classical sound field and the correspondence principle, paired phonon states in the free phonon approximation, the boson system at absolute zero, and nondiagonal matrix elements and perturbation formulas. The analysis is simplified, particularly in the treatment of the fermion liquid, by choosing the correlation factor in the correlated basis to be the ground-state boson-type solution of the Schroedinger equation associated with the real physical problem under study. (M.H.R.)

**17867** CURRENT VORTICES IN SUPERCONDUCTING FILMS AT THE SURFACE PARALLEL CRITICAL FIELD. Schultens, H. A. (Univ., Goettingen, Ger.). Z. Phys.; 232: 430-8(1970).

An idealized superconducting film in a homogeneous magnetic field parallel to the surface is considered in the range of validity of the linearized Ginzburg–Landau equation. The invoking of a simple symmetry principle leads directly to the existence of current vortices (flux tubes) for certain thicknesses and field strengths. Streamlines of the supercurrent for numerical solutions of the equations are shown. (auth)

**17868** FLUCTUATIONS IN SUPERCONDUCTORS BELOW $T_c$. Schmidt, Hartwig (Technische Hochschule, Munich). Z. Phys.; 232: 443-51(1970).

Thermal fluctuations of the order parameter in the superconducting state are investigated, particularly near the transition temperature, using the time dependent Ginzburg–Landau theory. These fluctuations give rise to a contribution of the dynamical conductivity, which strongly increases as the temperature is raised towards $T_c$, in contrast to the temperature dependence of the electromagnetic response due to the static order parameter. At the transition temperature this contribution joins continuously to the extra response (conductivity, susceptibility) which has been calculated and observed in the temperature region above $T_c$, where it represents the onset of superconductivity in the normal state. Particularly the dynamical conductivity due to fluctuations is calculated and discussed for bulk material, thin films and thin wires below $T_c$. The temperature and frequency dependence should be observable in microwave experiments. (auth)

**17869** THEORY OF JOSEPHSON DETECTION. Likharev, K. K. Vestn. Mosk. Univ., Ser. III. Fiz. Astron.; No. 6, 83-91 (Nov-Dec 1969). (In Russian).

The influence of harmonic external signals on a system of a resonator connected by weak contacts to two superconductors with Josephson or ordinary current flow was examined. A method of slowly changing amplitudes was used for calculating oscillation parameters in the system and the volt–ampere characteristics of the contacts and their changes during supply of external signals. The sensitivity and inertia of such detection devices were analyzed. (tr-auth)

## Plasma and Thermonuclear Physics

*Refer also to abstract 16929.*

**17870** (AEC-tr-6931/7) NUKLEONIKA. Translation of Nukleonika; 13: No. 7, 719-826(1968). 102p. (TT-68-50011/7). Dep. CFSTI.

Main trends are presented of research on hot plasma physics developed in the Institute of Nuclear Research, Swierk. The experimental arrangements as well as the diagnostic methods used and general technical problems are described. A review of theoretical studies also is given. (auth)

**17871** PLASMA PHYSICS INDEX. VOLUME 4, NO. 12, 1969. Bibliography, Author Index, Subject Index. Frankfurt am Main; Zentralstelle fuer Atomkernenergie-Dokumentation (1969). 184p.

A listing of 319 references on various aspects of plasma physics is presented. (M.O.W.)

**17872** WAVE INTERACTIONS IN SOLID-STATE PLASMAS. Steele, Martin C.; Vural, Bayram. McGraw-Hill Advanced Physics Monograph Series. New York; McGraw-Hill Book Company (1969). 294p. $15.50.

Properties of solid-state plasmas and their wave interactions are presented from a unified point of view. This view is based on the consideration of the elementary excitation spectrum of the solid and the interaction of different excitations with each other. In order to develop and justify the basic model that will then be studied in detail both theoretically and experimentally, the concept of elementary excitations (quasi particles and collective modes) of the solid is first introduced. It is then shown that many of the bulk effects in solids may be described in terms of wave excitations and propagation due to collective behavior of these quasi particles. The description may be carried out in either classical or quantum-mechanical language. A semiclassical description is mainly used here since it is adequate up to very high frequencies. (M.O.W.)

**17873** MAGNITNYE LOVUSHKI. VYPUSK 4. (Magnetic Traps. Issue 4). Tolok, V. T. (ed.). Respublikanskii Mezhvedomstvennyi Sbornik. Fizika Plazmy i Problemy Upravlyaemogo Termoyadernogo Sinteza. Kiev; Naukova Dumka (1969). 92p.

Eleven articles are included on the theoretical and experimental studies of charged-particle injection and motion in various types of magnetic traps. The influence of the axial current on magnetic surfaces of a stellarator, axial electron beam interactions with magnetic fields, the effect of magnetic trap walls on plasma heating, studies of plasma created in mirror magnetic traps by plasma–beam discharges are discussed in the first section. The second section (on gas discharge) includes: self-containing synthesis reactions in low-temperature high-density plasma, studies on pulsed arcs in argon and helium at ultrahigh pressures, and configuration and heating of high-pressure electrodeless discharges. (R.V.J.)

**17874** PLASMA PHYSICS: TECHNOLOGY INDEX. VOLUME 3, NO. 12, 1969. Bibliography, Author Index, Subject Index, Appendix. Frankfurt am Main; Zentralstelle fuer Atomkernenergie-Dokumentation (1969). 86p.

A listing is presented of 177 articles on various aspects of plasma physics. (M.O.W.)

**17875** TECHNOLOGY INDEX FOR PLASMAPHYSICS RESEARCH AND FUSION REACTORS. VOLUME 4, NO. 1, 1970. Bibliography, Author Index, Subject Index, Appendix. Frankfurt am Main; Zentralstelle fuer Atomkernenergie-Dokumentation (1970). 44p.

A listing is presented of 185 articles on various aspects of plasma technology. (M.O.W.)

## *Confinement and Heating*

*Refer also to abstracts 16928 and 17980.*

**17876** CONTROLLED FUSION: PLASMA HEATING WITH LASERS. Holcomb, Robert. Science; 167: 1112-13(20 Feb 1970).

Developments in the use of lasers for plasma production and heating are discussed. The different research projects throughout the world are briefly described. (M.O.W.)

**17877** DRIFT DURING SIMPLE TOROIDAL THETA-PINCH COLLAPSE. Fujisawa, Noboru; Ito, S. (Nagoya Univ., Japan). Denki Gakkai Zasshi; 89-5: 926-30(May 1969). (In Japanese).

The collapse process of plasma produced by the simple toroidal theta pinch was calculated for the case of variable condenser voltage using snowplow model. Electrical conductivity of the plasma was assumed to be infinitely large. The basic partial differential equations for plasma cross section, velocity, and density at the plasma surface were derived. The derived equations could not be solved exactly, so that numerical calculation was made for various aspect ratios, and the result was illustrated. The result showed that the plasma column was displaced towards the outer wall, and the shape of the cross section changed into a heart shape due to the nonuniformity of the magnetic field. For aspect ratio larger than 10, this deformation was negligible, and the shift to the outer wall was also negligible. It was concluded that the simple toroidal theta pinch can be regarded as a linear theta pinch when the aspect ratio is larger than 10. This provides the design criterion for the toroidal theta pinch. (NSA of Japan)

**17878** NONRESONANT ABSORPTION OF ELECTROMAGNETIC WAVES IN A HIGH-DENSITY PLASMA. Lisitano, G. (Institut fuer Plasmaphysik, Garching, Ger.); Fontanesi, M.; Sindoni, E. Appl. Phys. Lett.; 16: 122-4(1 Feb 1970).

Efficient radio-frequency heating of a high-density plasma is obtained for any value of the containing magnetostatic field larger than that corresponding to electron cyclotron resonance. (auth)

**17879** EFFECT OF MAGNETIC FIELD ON DISCHARGE PLASMAS AND ION LASERS. Keller, John Howard. Salt Lake City; Univ. of Utah (1969). 143p.

Thesis.

Theoretical descriptions are obtained for the effects of both uniform and nonuniform magnetic fields on discharge plasmas and ion lasers. These theories include a comprehensive derivation of nonlinear ambipolar diffusion, theory including the effects of charge separation and ion acceleration, the effect of a uniform magnetic field on the plasma when the ion mean free path is approximately equal to or less than the tube radius, and the effect of a nonuniform magnetic field. The theory shows that the definition of the ion mobility should include the ionization frequency. Microwave cavities and double probes were used to measure the electron temperature and density. A comparison between the theory and the experimental data gives excellent agreement for both uniform and nonuniform magnetic fields. Equations are also given for calculating plasma properties, such as ion mobility, from the experimental data. Applications of the theory are made to ion lasers and to the design of more efficient and/or higher power argon lasers. Special attention is given to the design of an ion laser which uses widely spaced segments and a magnetic field to confine the plasma. The experimental results obtained with the laser show that this design should produce more-efficient 4- and 5-mm bore ion lasers and also show a need for larger than normal gas return paths. Calculations indicate that the efficiency may be increased by a factor of 2.5 by using widely spaced segments and a magnetic field to confine the plasma in an ion laser. (Diss. Abstr. Int., B)

**17880** ENERGY AND PARTICLE LOSS FROM A SHORT THETA PINCH. Jones, W. B.; Goldman, L. M.; Kilb, R. W.; Bingham, R. L. (General Electric Research and Development Center, Schenectady, N. Y.). Phys. Fluids; 13: 800-9(Mar 1970).

The axial and temporal variation of the electron density and temperature were measured in a 0.5-m-long theta pinch with a 14.5-μsec half-cycle duration by means of laser light scattering. The plasma diameter and diamagnetic flux signal were also measured. A fairly flat peak of the electron temperature of ~160 eV is found from 2 to 6 μsec inside the mirror coil. The density is more sharply peaked, both in axial and temporal variation, with a maximum of $3.2 \times 10^{16}$ electrons/cm$^3$ at the centerplane from 3 to 4 μsec. The predominant energy loss is the energy transport associated with the particle loss (e-folding time of 1.5 μsec) in this relatively short theta pinch, but electron heat conductivity does result in an energy loss of 50 to 150 eV/μsec per electron. Ion–electron heat transfer from the hotter ions to the cooler electrons nearly balances the electron heat flow. From the electron temperature and density profiles and using the electron momentum balance equation, the plasma potential was derived and found to be approximately 450 V at the centerplane from 2 to 6 μsec. A magnetohydrodynamic model computation for this experiment has been made which shows that the parallel electron heat conductivity as given by Spitzer and Landshoff is correct to no worse than a factor of 10, and possibly a factor of 3. The computations also show that the amount of magnetic flux trapped in the plasma cannot be constant but either decreases with time or is nonuniformly embedded in the plasma at the end of the initial implosion. (auth)

**17881** FLUCTUATIONS AND PARTICLE LOSS IN THE SPHERATOR. von Goeler, S.; Sadowski, M.; Pacher, H.; Yoshikawa, S. (Princeton Univ., N. J.). Phys. Fluids; 13: 790-4(Mar 1970).

The relation between particle loss and fluctuation level is studied. Stable discharges are found in hydrogen under conditions of long mean free path and high shear, and with gases of high mass under almost all conditions. A comparison is made

of the plasma loss in stable and unstable regions. Wave diffusion is estimated from correlation measurements. Particle loss rate and fluctuation level are found to be essentially uncorrelated. (auth)

**17882** ION TEMPERATURES AND INCREASED END LOSSES IN Q DEVICES. von Goeler, S.; Motley, R. W. (Princeton Univ., N. J.). Phys. Fluids; 13: 834-7(Mar 1970).

Negative plasma potentials and imperfect radial plasma confinement in Q-machine alkali plasmas disturb the plasma equilibrium, raising the ion temperature and the end losses. Calculations pertinent to typical cesium and potassium plasma columns are presented. (auth)

**17883** EQUILIBRIUM DIFFUSION RATE IN A TOROIDAL PLASMA AT INTERMEDIATE COLLISION FREQUENCIES. Stringer, T. E. (Culham Lab., Abingdon, Eng.). Phys. Fluids; 13: 810-19(Mar 1970).

It is shown that a consistent equilibrium must include an azimuthal electric field. The ambipolar diffusion rate differs in several respects from earlier estimates, although these differences are not primarily due to the azimuthal field. The new rate tends to be lower. In a stellarator field an ambipolar condition may occur in which the electron diffusion due to the toroidal field variation balances the ion diffusion in the helical variation. (auth)

## Diagnostics

*Refer also to abstracts 16925, 16927, and 16930.*

**17884** (CEA-CONF-1344) LIGHT SCATTERING FROM THE PLASMA OF THE FOCUS MACHINE. Baconnet, J. P.; Cesari, G.; Coudeville, A.; Watteau, J. P. (Commissariat a l'Energie Atomique, Villeneuve-Saint-Georges (France)). [nd]. 8p. (In French). (CONF-690431-1). Dep. CFSTI (U. S. Sales Only).

From Discussions of the Diagnostic Group of Plasmas, Fontenay-aux-Roses, France.

The scattering of a monochromatic light wave from a ruby laser by the electrons of a deuterium plasma was measured. The results were analyzed by a least squares method in an attempt to find the best theoretical spectral profile corresponding to the experimental points. This gives the ion temperature of the plasma which varies according to the case between 250 and 400 eV, 80 eV < $T_e$ < 150 eV and $n_e > 3 \times 10^{18}$ cm$^{-3}$. (J.S.R.)

**17885** STUDY OF PARAMETERS OF LOW-DENSITY NONEQUILIBRIUM PLASMA WITH A THERMO ANEMOMETER–LANGMUIR PROBE. Shuvalov, V. A. (Dnepropetrovsk Inst. of Tech., USSR). Inzh.-Fiz. Zh.; 17: 1050-7(Dec 1969). (In Russian).

A method for diagnostics of nonequilibrium rarefied plasma with a thermoanemometer–Langmuir probe is proposed. The technique is used for determination of local parameters of nonequilibrium high-frequency discharge plasma in helium. The experiments were carried out at pressures of 0.07, 0.12, and 0.20 mm Hg without magnetic field. Diagnostics with Langmuir probes allowed determination of the main local plasma parameters such as temperature of electrons, ions, and neutrals and density of charged and neutral particles and plasma potential. (auth)

**17886** INTERFEROMETER MEASUREMENTS OF PULSED XENON DISCHARGE PARAMETERS. Bakeev, A. A.; Narozhnaya, T. P.; Rovinskii, R. E.; Cheburkin, N. V. Radiotekh. Elektron.; 14: 1998-2004(Nov 1969). (In Russian).

Functions of neutral and charged particles in pulsed-discharge plasma in xenon were obtained by means of a three-mirror laser interferometer during probing with two long waves. It was found that at the initial moment of the discharge, up to 70% of the neutral atoms are pushed out near the electrode regions, their number depending on the discharge regime, with atom returning time ~100 msec. At the diminishing part of the pulsed current, the temperature is uniquely bound to the current density by a power function, i.e., the temperature varies as a function of the fifth power. (tr-auth)

**17887** TEMPERATURE MEASUREMENTS OF DENSE XENON PLASMA BY TWO INDEPENDENT METHODS. Bakeev, A. A.; Rovinskii, R. E.; Shirokova, I. P. Teplofiz. Vys. Temp.; 7: 1203-5(Nov-Dec 1969). (In Russian).

An attempt was made of measuring the charged and neutral particles in a xenon discharge using a three-mirror interferometer operating with 0.63- and 3.39-$\mu$ waves. The obtained time functions $n_e$ and $n_a$ were used with the Saha equation for determining discharge temperature with the assumption that the electron and neutral atom concentrations remain constant along the tube radius and that the Saha equation holds in the given conditions. Measurements were carried out in a discharge 7 mm in diameter and 80 mm long at a cold gas pressure of 400 mm Hg. Data obtained were compared with measurements of discharge temperature by means of Kirchhoff's law, based on absolute measurements of the absorption coefficient and intensity of discharge emission in the direction perpendicular to the axis of the discharge, and assuming that plasma is homogeneous in this direction. Temperature values obtained by each method were almost identical. (R.V.J.)

**17888** INFLUENCE OF TEMPERATURE OF DOUBLE NONEMITTING PROBE ON MEASUREMENTS OF ELECTRON TEMPERATURE AT MEAN AND HIGH PRESSURES. Vasil'eva, I. A. (Lebedev Inst. of Physics, Moscow). Teplofiz. Vys. Temp.; 7: 1053-60(Nov-Dec 1969). (In Russian).

Approximation calculations were made of temperature distribution of electrons inside a thermal perturbation layer of heavy plasma. The method of successive approximations was used for resolving the equation of electron energy balance in which electron heat conductance is of greater importance than the volume electron interaction with the heavy particles. Electron heating by arc currents was also considered. In the case in which the area of the space charge near the double probe is much smaller than the area of thermal perturbation, the calculated distribution helps to correlate the electron temperature with that measured by the double probe method. The calculations showed the order of error of the probe method. (tr-auth)

**17889** MEASURING OF PLASMA DENSITY WITH AN OSCILLATORY CIRCUIT. Sinitsa, N. G. (Inst. of Physics and Tech., Kharkov). Ukr. Fiz. Zh.; 14: 2052-8(Dec 1969). (In Russian).

The resistance and resonance frequency of an oscillatory circuit is calculated in hydrodynamical approximation when the plasma without a magnetic field is placed into an inductive coil. (auth)

**17890** INVESTIGATION OF A PLASMA CLUSTER CREATED BY FOCUSING LASER RADIATION. Korneev, N. E.; Pavlov, Yu. I.; Rumyantseva, I. A. (Inst. of High Temperatures, Moscow). Teplofiz. Vys. Temp.; 7: 167-8(Jan-Feb 1969). (In Russian).

A so-called spark-generated plasma cluster, created by the focusing of a laser with a modulated resonator, was subjected to spectroscopic study. The time-averaged electron concentration and temperature of the plasma were determined by means of a doubly elliptical illuminator; the radiant energy was measured by the calorimetric method. The spectrograms obtained revealed that singly ionized nitrogen and oxygen atoms were present. The N II 5179 and 5045 Å lines of nitrogen were used estimating the temperature. Although in earlier studies a wide spread was noted for the 30,000 to 60,000°K temperature range, the spread found in the individual measurements during this study did not exceed ±2000°K, thus lying within the limits of experimental error. The $n_e$ value was found to be $6 \times 10^{18}$ cm$^{-3}$. The temperature and density values indicate that the plasma is in a decay state. During the initial stages of the spark, for a few nanoseconds, much larger temperatures and electron concentrations were expected. (TTT)

**17891** THEORY OF THE PLANE PLASMA RESONANCE PROBE. Li, Nelson C. (Texas A and M Univ., College Station); Gustafson, W. A. Phys. Fluids; 13: 652-6(Mar 1970).

The response of a semi-infinite plasma adjacent to an infinite plane probe is established theoretically when a small-amplitude alternating potential is superposed on a dc potential. The dc potential distribution in the sheath is found by solving Poisson's equation making use of Bohm's sheath criterion. The linearized Boltzmann–Vlasov equation for electrons along with the appropriate Maxwell equations are used to formulate a linear integral equation for the perturbed electric field. The average dc electron current is computed which indicates a maximum value (resonance) that depends on the probe potential for frequencies less than the plasma frequency. (auth)

**17892** MEASURING METHOD FOR COLLISION FREQUENCY BY A RADIO-FREQUENCY PROBE. Uramoto, Johshin (Nagoya Univ., Japan). Phys. Fluids; 13: 657-60(Mar 1970).

A method of determining the electron–neutral collision frequency in a low-density plasma is discribed. A radio-frequency signal of constant frequency and voltage is applied between plane probes while the plasma density is varied to determine an antiresonance point, i.e., a current minimum. Compared with the ordinary resonance probe method using the resonance peak halfwidth, the new method is insensitive to external circuit impedance and avoids the perturbing effect of the strong rf fields at resonance. (auth)

**17893** PLASMA VELOCITY DETERMINATION BY ELECTROSTATIC PROBES. Johnson, Billy H.; Murphree, David L. (Mississippi State Univ., State College). AIAA (Amer. Inst. Aeronaut. Astronaut.) J.; 7: 2028-30(Oct 1969).

In a flowing plasma, the ion current collected by a cylindrical electrostatic probe is a function of the angle between the longitudinal axis of the probe and the velocity sector of the plasma. This velocity dependence is used to develop a method of determining the velocity of a flowing plasma from the Langmuir curves of two mutually perpendicular probes. Langmuir probe measurements were performed in a supersonic argon plasma stream to determine the feasibility of this method; the Mach number thus determined was compared with that determined by an independent method. (D.L.C.)

**17894** MEASUREMENTS OF RADIAL TEMPERATURE DISTRIBUTIONS IN THE $N_2$ CASCADE ARC UP TO 26,000 °K. Schade, E. (Technische Hochschule, Munich). Z. Phys.; 233: 53-64(1970). (In German).

On a stationary, flowless and cylindrical nitrogen arc (1 atm, 5 mm Ø), the radial temperature distributions are measured spectroscopically for the current range of 5 to 570 A in steps of between 5 and 50 A. At the highest current of 570 A the power input amounts to 18 kW/cm arc length and to 12 kW/cm² wall load. The temperatures attain a maximum of 26,000°K corresponding to a degree of ionisation of 115%. The emission of N III-lines confirms the occurance of a partially double ionisation of the nitrogen. The intensities of molecular bands together with several N I- and N II-lines are measured side on by means of electronic registration, while that of the line N III 4103 Å is recorded photographically. (auth)

**17895** SHAPE AND SHIFT OF THE RESONANCE LINES OF $Ca^+$ PRODUCED BY ELECTRON COLLISIONS. Barnes, K. S.; Peach, G. (University Coll., London). Nature (London); 225: 374-5(24 Jan 1970).

The shape and shift of spectral lines can be used to determine the temperature and particle density of laboratory and astrophysical plasmas. For the case where the perturbers of the emitting atomic systems are electrons many semi-classical calculations of the impact broadening of spectral lines have been carried out, but the quantum mechanical theory of Baranger (Phys. Rev. 111: 481, 494 and 112: 855(1958)) has not been applied. Burke and Moores (J. Phys. B 1: 575(1968)) applied the close-coupling approximation to the scattering of electrons by $Mg^+$ and $Ca^+$ ions; the results for $Ca^+$ are used by the present authors to make the first completely quantum mechanical calculations of the effect of electron impact on the resonance lines of this ion. Reasonable agreement is obtained with the semiclassical results, but both theoretical results considerably overestimate the width and shift as compared with experiment. It may be that experimental determinations should be reexamined. (UK)

## *Kinetics (General)*

**17896** (NP-18145) DIFFUSION IN EXPERIMENTS ON HIGH-FREQUENCY STABILIZED PLASMA. Dubovoi, L. V.; Shanskii, V. F. (Scientific Research Inst. of Electro-Physical Apparatus, Leningrad (USSR)). 1969. 16p. (In Russian). Dep. CFSTI (U. S. Sales Only).

The diffusion coefficient of charged particles was measured in order to determine the high-frequency stabilization of the Kadomtsev–Nedospasov current-convective instabilities in electron–hole plasma in germanium semiconductors. The diffusion coefficient was obtained on the basis of the spatial distribution of particles in plasma, measured by the method of free-carrier absorption of He–Ne laser infrared emission. It is shown that the high-frequency stabilization results in reduction of the anomalous diffusion coefficient down to the magnitudes close to those measured in the case of steady-state plasma. (tr-auth)

**17897** THEORETICAL AND EXPERIMENTAL INVESTIGATION OF THE COLLISIONLESS PLASMA SHEATH. Yamada, Hideo. State College, Miss.; Mississippi State Univ. (1969). 129p.

Thesis.

Plasma sheath equations were derived under the following assumptions, i.e., (1) one-dimensional, (2) collisionless, (3) Maxwellian velocity distributions of charged particles at the sheath edge, (4) perfectly conducting sheath plate, (5) two-species gas (electrons and ions), (6) static, and (7) no magnetic field. The experiment was conducted in a glow-discharge-produced argon plasma of 0.2 ~ 0.8 μHg pressure. A movable probe of 0.0025-inch diameter, 0.25 inch in length, tungsten wire was utilized to determine the sheath properties of a 1.25-inch diameter sheath-forming, conducting plate. Several examples of the comparison between the theory and the experiment are presented. The results were observed to agree more for the sheath of positive plate than for the sheath of negative plate. This tends to confirm the theoretical and experimental method employed for the sheath of positive plate. (Diss. Abstr.)

**17898** MEASUREMENTS OF ELECTRICAL AND THERMAL CONDUCTIVITY OF HYDROGEN, NITROGEN, AND ARGON AT HIGH TEMPERATURES. Morris, J. C.; Rudis, R. P.; Yos, J. M. (Avco Corp., Wilmington, Mass.). Phys. Fluids; 13: 608-17 (Mar 1970).

The electrical and thermal conductivities of hydrogen, nitrogen, and argon were measured up to 14,000°K for pressures between 0.5 and 2.0 atm using a wall-stabilized electric arc as a plasma source. Generally satisfactory agreement is noted between theory and experiment for the electrical conductivity. Equally good agreement is found for the thermal conductivity for nitrogen and argon when the energy transfer by vacuum-ultraviolet radiation is included in the energy transport calculations. For hydrogen a difference between theory and experiment of as much as a factor of 2 is observed at the lower temperatures; this difference is dependent on arc current and may be the result of nonequilibrium effects. (auth)

**17899** INTERACTION OF HYDROMAGNETIC WAVES WITH HYDROMAGNETIC SHOCKS. McKenzie, James F. (Univ. of California, San Diego, La Jolla). Phys. Fluids; 13: 630-40 (Mar 1970).

The problem of the interaction of small-amplitude plane hydromagnetic waves with plane, oblique hydromagnetic shocks is treated. When the perturbations of the flow field on either side of the shock are expanded in terms of incident and diverging eigenwaves, the linearized de Hoffmann–Teller relations across the shock yield a system of equations for the amplitudes of the diverging waves and the motion of the perturbed shock. The shock motion and the amplitudes of the diverging waves as a function of the amplitude and direction of any given incident wave are found using this system of seven linear, inhomogeneous equations, along with Snell's laws. Snell's laws are interpreted graphically by making use of the geometry of the hydromagnetic wave normal surfaces in a moving medium. By considering some special cases it is shown that hydromagnetic waves are amplified on passage through a fast shock. The turbulent character of the region between the bow shock of the earth and the magnetopause may be due in part to the amplification of turbulent waves in the solar wind on passing through the bow shock. (auth)

**17900** DIRECT MEASUREMENT OF THE ION DISTRIBUTION FUNCTION IN A TOROIDAL OCTUPOLE. Erickson, C. W. (Univ. of Wisconsin, Madison). Phys. Fluids; 13: 819-26(Mar 1970).

The distribution function was found to be a function only of energy and canonical angular momentum $P_\theta$ thus automatically satisfying the Vlasov equation, and being consistent with the assumption of a collisionless plasma. The lifetime of the plasma was inversely proportional to ion velocity and directly proportional to accessible phase space volume. The lifetime of 40-eV ions confined in the field was about 500 μsec which is consistent with the interpretation that the plasma is gradually lost to the supports of the current-carrying hoops although it is known that other losses to walls also occur. Density and current were calculated from the appropriate moments of the measured distribution. Plasma is confined primarily in the low-field central region of the octupole, and the density drops rather sharply in the outer regions of higher field, in the horizontal midplane of the device. The only component of ion current was the azimuthal one, which had a maximum value of about $10^{-4}$ A cm$^{-2}$ and indicated a net mass flow in the positive $\theta$ direction. (auth)

**17901** MEASUREMENTS OF THE ION-ELECTRON EMISSION FACTOR IN A DISCHARGE WITH OSCILLATING ELECTRONS. Reikhrudel, E. M.; Smirnitskaya, G. V.; Mavlyanov, A. N. Vestn. Mosk. Univ., Ser. III. Fiz. Astron.; No. 6, 46-52 (Nov-Dec 1969). (In Russian).

Measurements averaged along the cathode surfaces of the coefficients of secondary ion–electron emission in an oscillating-electron discharge are presented. The averaged coefficients are correlated for various materials (Al, Ag, Be, Bi, Cu, In, Nb, Ti, Ta, Re, Zr, and W) and compared with that of molybdenum. Effective secondary emission coefficients for the first discharge regime at various gas pressures were determined. (tr-auth)

**17902** ON MECHANISM OF CYCLOTRON EMISSION FROM PLASMA OF REFLECTING DISCHARGE. Kuznetsov, Yu. K.; Pavlichenko, O. S.; Starikov, V. N. (Inst. of Physics and Tech., Kharkov). Ukr. Fiz. Zh.; 14: 1786-91(Nov 1969). (In Russian).

Nature of emission of electron cyclotron frequency harmonics from PIG discharge is discussed. Main properties of emission are explained by electron cyclotron wave instability of plasma containing a group of non-thermal electrons. (auth)

## Kinetics (Experimental)

**17903** EXPERIMENTS ON THE ELECTRICAL CONDUCTIVITY OF PLASMAS PRODUCED BY A COMBUSTION-DRIVEN SHOCK TUBE. Shibata, Koki; Iwasaki, Matsunosuke (Kyushu Univ., Fukuoka). Kyusnu Daigaku Kogaku Shuho; 42: 691-8(Aug 1969). (In Japanese).

Electric conductivity of the plasma produced by a combustion-driven shock tube was measured by the method of Lin et at. Mixture of $H_2$, $O_2$, and He at pressures 5 to 20 kg/cm$^2$ was used as the driving gas. The low-pressure-driven gases were Ar at initial pressures of 2, 5, 10, 20 mm Hg and air at pressure of 1 to 5 mm Hg. Disturbance of the magnetic field due to the plasma flow behind the shock wave was detected with a search coil. Shock velocity and particle velocity were measured with streak-camera photography. Examples of signals from the search coil at 3.3 m from the diaphragm are shown. For Mach number below 10, stepped discontinuity was found in the plasma behind the shock wave. Electric conductivity is plotted against the calculated temperature. Good agreement with the theory of Chapman and of Spitzer is obtained. Calibration of the search coil was made using an aluminum rod accelerated with compressed air. For Ar, the responsive signal of the plasma was very much reduced (~1/100) at 4.8 m from the diaphragm. (NSA of Japan)

**17904** ELECTRON DENSITY IN THE OXYGEN DISCHARGE PLASMA. Rezacova, V. (Charles Univ., Prague). Czech. J. Phys.; 20: 126-31(1970).

The electron density in two forms of the oxygen plasma positive column is determined. These two forms differ in the gradient of the potential of the axial electrical field. The electron density is measured by means of a microwave toroidal resonator. In the form with higher gradient (so-called "H" form), a lower electron density than in the form with lower gradient (so-called "T" form) is found. The electron density in the two types of oxygen discharge plasma, which differ in cathode fall, is measured too. (auth)

**17905** CURRENT PATTERN AND GAS FLOW STABILIZATION IN PULSED PLASMA ACCELERATORS. Eckbreth, Alan Charles. Princeton, N. J.; Princeton Univ. (1969). 221p.

Thesis.

Spatial stabilization of the formerly propagating current patterns in the exhaust plume of a linear pinch discharge device fitted with an anode exhaust orifice has led to the construction of a parallel-plate accelerator in which this phenomenon can be more conveniently studied. Stabilization of a propagating current sheet driven by a 120,000 ampere × 20 sec rectangular current pulse is precipitated by partially insulating the electrodes. Stabilization of the current sheet at the electrode to insulator discontinuity is studied with Kerr cell discharge and wedge flow photography, magnetic and electric field probes, and terminal voltage measurements. These measurements indicate the stabilized discharge continues to accelerate gas through itself as long as gas from the prior prefilling of the discharge chamber remains. A shock tube gas injection technique is used to supply fresh gas to the stabilized current discharge. It is found that the current must be driven for hundreds of microseconds before a steady gas flow can be established in contrast to the tens of microseconds time scale required for electrodynamic stabilization. The quasi-steady flow mode in which both current pattern and gas flow stabilization coexist, is studied with the above-mentioned diagnostic techniques, and the discharge is again found to accelerate the inlet flow. (Disser. Abstr.)

**17906** PARAMETERS FOR CROSSED-FIELD STATIONARY ACCELERATORS AT MEDIUM PRESSURE. Konakh, V. F. Teplofiz. Vys. Temp.; 7: 1201-3(Nov-Dec 1969). (In Russian).

Descriptions are given on the design and performance of a MGD accelerator with additions of cesium. Measurements were made of the accelerator parameters: current and arc intensities, electric longitudinal and Hall fields, argon and cesium pressure, magnetic fields, and the arc current magnitude. Gas flow velocity increased linearly with the number of arcs; with increased gas pressure, the flow rate in the circuit diminished. (R.V.J.)

**17907** PROBLEMS OF SPECTRAL DISTRIBUTION OF RADIATION LOSSES IN PULSED PLASMA ACCELERATORS. Derevshchikov, V. A.; Struchkov, A. I. Teplofiz. Vys. Temp.; 7: 1205-8(Nov-Dec 1969). (In Russian).

A low-inertia counter used previously for measuring plasma radiation losses was capable of only partially eliminating the distortions related to the radiation particle bombardment of the counter. Separation of bombardment and radiation effects was partially achieved by a bolometer. An attempt was made of achieving a complete separation of the effects by using a vacuum photoelectric radiation detector with a metallic photocathode. Design and operation of the experimental device, oscillograms of the discharge current, and photoelectric signals for a coaxial model are given. Quantitative calculations made with the assumption of uniform frequency distribution of radiation energy showed that the fraction of radiation losses for a coaxial model in the spectral range 200 to 1200 Å did not exceed 3 to 5% of the energy stored in capacitors, which is in good agreement with bolometric measurements. (R.V.J.)

**17908** STUDIES OF DENSE PLASMA IN HIGH-PRESSURE PULSED ARCS. II. DETERMINATION OF PLASMA DENSITY. Mitin, R. V.; Kantsedal, V. P. (Physical-Technical Inst., Kharkov). Teplofiz. Vys. Temp.; 7: 1066-70(Nov-Dec 1969). (In Russian).

Parameters of dense plasma formed in pulsed electric arcs 6 cm long at 20 to 40 atm pressure, ~45 kA current, and pulse duration of 0.7 m/sec were determined. The discharge was initiated by use of a copper wire 0.3 mm in diameter. Discharges in Ar, He, and $H_2$ at 40 atm pressure were studied and the relation between the arc diameter and time was determined. Pressure variations during the discharge time were recorded by a piezotransducer. Probes were used to measure the current density, temperature, and ionization distribution along the arc radius. (tr-auth)

**17909** THE FLOW OF A TWO-SPECIES PLASMA IN A CYLINDRICAL TRAVELING-WAVE ACCELERATOR. Enseki, Fred Kazuo. Morgantown, W. Va.; West Virginia Univ. (1969). 150p.

Thesis.

The majority of the theoretical analyses that have been performed in regard to the fluid-dynamic characteristics of the MHD traveling-wave accelerator have utilized a global flow approach to the problem. The use of such a global approach results in the determination of the mass average motion and net electric current in the plasma. However, the motions of the constituents which compose the plasma are not explicitly determined. In this paper these species motions for the case of a fully ionized gas composed of electrons and singly ionized, positive ions are determined. (Diss. Abstr.)

**17910** SIMPLE METHOD FOR OPERATING A THETA PINCH IN A VERY LOW-PRESSURE REGION. Hayase, K.; Okuda, T. (Nagoya Univ., Japan). J. Phys., D (London); 3: L12-13(Mar 1970).

A preionization for the theta-pinch in a very low-pressure region is attained by adding an auxiliary discharge circuit to the usual z-discharge circuit. By applying this method, the contraction time of a theta pinch in a wide pressure region is measured. Its dependence on the gas pressure shows a certain anomaly below 0.5 mtorr. (auth) (UK)

**17911** DENSITY FLUCTUATIONS AND LONGITUDINAL CONDUCTIVITY OF A WEAKLY IONIZED TURBULENT PLASMA IN A MAGNETIC FIELD. Tsukishima, T.; Mase, A.; Takeda, S. (Nagoya Univ., Japan). Phys. Fluids; 13: 649-51(Mar 1970).

The collision frequency $\nu_t$ of an electron with turbulent waves is found to increase linearly with the mean square of the density fluctuation of the electrons in a turbulent positive column. $\nu_t$ becomes as large as 10 times the electron–neutral collision frequency $\nu_{en}$. (auth)

**17912** PLASMA ELECTRICAL CONDUCTIVITY IN A MAGNETIC FIELD FROM HALL EFFECT AND FROM SOLENOIDAL ELECTRIC FIELD INTERACTION. Albares, Donald Joseph. Boulder, Colo.; Univ. of Colorado (1969). 107p.

Thesis.

The electrical conductivity of a partially ionized dc plasma in a dc magnetic field was investigated by two independent experimental methods, one utilizing the Hall effect and the other a plasma interaction with an induced solenoidal electric field. Quantities inferred for the first time using these methods were the electron–ion momentum transfer collision frequency, ion mobility in the magnetic field, and the combinations of these two with the electron–atom momentum transfer collision frequency. The objective was to study these quantitatively at low frequency (~100kHz) under conditions of improved symmetry, control, and stability. The helium abnormal negative glow plasma was used at gas pressures of 0.5 to 2.5 torr and electron densities of ~1.0 to 32 × 10$^{17}$ m$^{-3}$; the magnetic field ranged up to 675 gauss. It is concluded that the data support Shkarofsky's theory of partial ionization where it is applicable. When a term borrowed from simple theory to account for ion mobility in the magnetic field becomes dominant, the resulting ion mobility is 75% larger than the $He^+$ mobility in helium taken from drift-tube measurements. This disagreement suggests that further theoretical work on ion mobility in a plasma in a magnetic field is needed. (Diss. Abstr.)

**17913** OBSERVATIONS IN THE TRANSITION ZONE OF A TURBULENT PLASMA JET. Demetriades, Anthony; Doughman, Ernest L. (Philco-Ford Corp., Newport Beach, Calif.). AIAA (Amer. Inst. Aeronaut. Astronaut.) J.; 7: 1646-8(Aug 1969).

Electron fluctuations in a weakly ionized Ar jet discharged into a vacuum tank were studied. The jet, initially supersonic and laminar, becomes turbulent several nozzle exit diameters from the exit. Langmuir probes and hot-wire anemometers were used to measure the intermittency and turbulence, thus mapping the electron density and temperature fluctuations. Two different regimes of turbulent flow could be distinguished. The density fluctuations in the transition region are intense and spiky in waveform. A schematic reconstruction of the axial variation of electron density is presented. (D.L.C.)

17914 EXPERIMENTAL STUDIES OF THE INTERACTION BETWEEN COLLISIONLESS PLASMAS AND ELECTROMAGNETIC FIELDS. Cohen, Leonard G.; Karlsson, Sture K. F. (Brown Univ., Providence). AIAA (Amer. Inst. Aeronaut. Astronaut.) J.; 7: 1446-53(Aug 1969).

A laboratory experiment was set up to study the steady-state interaction between a collisionless plasma flow and immersed stationary magnetized or unmagnetized objects, analogous to space probes and satellites immersed in the solar wind. A three-grid electrostatic cesium ion accelerator neutralized with a thoriated tungsten filament was inserted into an evacuated plasma wind tunnel and served as the steady source of collisionless plasma wind. Properties of the freestream were controlled through the bias voltages applied to the three grids and the electron emitter. Mobile probes were inserted into the plasma for three-dimensional internal measurements. A cylindrical Langmuir probe measured ion flux. A particle-flux probe, patterned after a Faraday cup and calibrated against the Langmuir probe, measured the angular divergence of the beam as well as the components of ion and electron flux directed along the axis of the plasma wind tunnel. Ion flux measurements, made with a permanently magnetized object inserted into the freestream, indicated the existence of a critical ion density, $2 \times 10^7 < n_{min} < 1.3 \times 10^8$ ions/cm$^3$, which, if exceeded, enabled the object to be magnetically shielded from the plasma stream. When the ion density was less than $n_{min}$, internal electric fields due to charge separation were insufficient to affect ion trajectories. Ion motion was then unperturbed by the magnetic field, because the cesium ion Larmor radius was large even when compared to the width of the plasma wind tunnel. (auth)

17915 STATIONARY COLLISIONLESS SHOCK WAVES IN AN INITIAL PLASMA WITH HIGH ION TEMPERATURE. Kornherr, Manfred (Institut fuer Plasmaphysik, Garching, Ger.). Z. Phys.; 233: 37-52(1970).

Stationary collisionless shock waves propagating perpendicularly to an initial magnetic field are produced by the fast-rising magnetic field ($\dot{B} = 7 \times 10^{10}$ G/sec) of a theta pinch (coil diameter 16 cm, coil length 60 cm). The initial plasma is produced by a fast theta pinch discharge (810 kHz). At filling pressures between 5 and 15 mtorr $H_2$ or $D_2$ the degree of ionization is about 50%. By choosing the filling pressure properly it is possible to trap a homogeneous magnetic field. The ions of this plasma have a temperature of a few 10 eV. This value is much higher than the electron temperature and results in a local plasma $\beta$ between 0.3 and 5. In this initial plasma stationary collisionless shock waves with Mach numbers between 1.5 and 5 are observed. The snow-plough model is used to derive conditions for the stationary state, attainable Mach number, and velocity of the front which relate the external magnetic field and the parameters of the initial plasma. Strong collisionless dissipation can be demonstrated by measuring the profiles of magnetic field, density, and electron temperature of the shock waves. For the electrons this dissipation mechanism can be described by an effective collision frequency. This phenomenologically introduced frequency determines the width of the shock front at least for subcritical shock waves. It exceeds the classical electron-ion collision frequency by 1 to 2 orders of magnitude and is roughly equal to one-third of the ion plasma frequency. The ion temperature can be estimated from the steady state conservation relations. The ions are heated in the two degrees of freedom perpendicular to the magnetic field. For shock waves with Mach numbers below the critical one the ions seem to be heated merely adiabatically. In strong shock waves this heating is considerably exceeded, and for high Mach numbers it yields ion temperatures up to about 500 eV. Finally, semi-empirical formulas are derived to estimate the possible temperatures of electrons and ions behind the shock front. (auth)

17916 ANODE-ADJACENT PRECURSORS IN ELECTROMAGNETICALLY DRIVEN CONVERGENT CYLINDRICAL SHOCK WAVES. Dammann, H. (Univ., Kiel); Kleist, G.; Kogelschatz, U.; Boetticher, W. Z. Naturforsch.; 24a: 1931-7(Dec 1969). (In German).

The precursor in front of the convergent cylindrical shock-wave of z-pinch discharges in helium and argon (diameter/length ratio: 44 cm per 10 cm) is investigated by interferometric methods. The precursors separate from the shock wave at higher filling pressures. It is found that the precursor exists only in a thin layer near to the anode. This effect can be explained by the assumption that the gas density in this region is lowered by a blast wave, which is formed in the early stages of the discharge by a still unknown process which depends on the sign of the discharge voltage. (auth)

17917 STUDIES OF LIMITED DISCHARGE WITH GLOWING CATHODE IN A MAGNETIC FIELD. Kozak, O. V.; Pasechnik, L. L. (Inst. of Physics, Kiev). Zh. Tekh. Fiz.; 39: 2177-82 (Dec 1969). (In Russian).

A discharge in helium in which a limited-cross-section incandescent cathode was used was studied. The range of pressure was $5 \times 10^{-3}$ to 0.2 mm Hg, plasma density from $10^9$ to $10^{14}$ cm$^{-3}$, and magnetic field varied from 0 to 5000 Oe. It is shown that beyond the axial region, determined by the cathode dimensions, the radial plasma density profile was determined by the longitudinal diffusion of charges (in plasma with density $>10^{12}$ cm$^{-3}$). At reduced pressure, starting with the pressure $\sim 5 \times 10^{-2}$ mm Hg, a discrepancy was observed between calculated and experimental data for diffusion coefficients in the direction perpendicular to the magnetic field. (tr-auth)

17918 STUDIES OF POLARIZATION OF PLASMA IN THE LOW-FREQUENCY REGION. Aleksandrov, A. F.; Kuzovnikov, A. A.; Sbiridkina, V. S.; Tarasova, V. V. (Moscow State Univ.). Zh. Tekh. Fiz.; 39: 2158-62(Dec 1969). (In Russian).

Experimental studies were made of perturbation of luminescence of low-pressure mercury plasma by superimposing low-frequency electric field. The results revealed the character of the plasma polarization. The polarization in the frequency region of the field $f \ll f_{Li}$ and $f \gg f_{Li}$ ($f_{Li}$ is Langmuir ion frequency) was interpreted as a transition from ion into electron polarization of the plasma. (tr-auth)

17919 LOW-PRESSURE ARC DISCHARGE MOTION BETWEEN CONCENTRIC CYLINDRICAL ELECTRODES IN A TRANSVERSE MAGNETIC FIELD. Murphree, David L.; Carter, Richard P. (Mississippi State Univ., State College). AIAA (Amer. Inst. Aeronaut. Astronaut.) J.; 7: 1430-7(Aug 1969).

A theoretical and experimental investigation of the Lorentz, stationary, and retrograde modes of motion of a low-pressure arc discharge is presented. It was found that an increase in the applied magnetic field strength will cause either an increase or a decrease in the arc's rotational speed, depending on the pressure. High-speed photography reveals the nature of the low-pressure arc kinematics for the aforementioned three modes of motion. The films show the cyclic structure by which these modes progress under the action of an applied transverse magnetic field. The effects of temperature nonequilibrium on the electrical conduction current density in the arc discharge are discussed. It is shown that in arc regions of high nonequilibrium with large spatial gradients in the electron temperature, electrical currents can occur in a direction opposite to that produced by the electromagnetic field alone. The various characteristics of the arc discharge are discussed as the results of temperature nonequilibrium. (auth)

17920 STABILITY AND SHAPE OF MAGNETICALLY BALANCED CROSS-FLOW ARCS. Benenson, David M.; Baker, Allen J. (State Univ. of New York, Buffalo). AIAA (Amer. Inst. Aeronaut. Astronaut.) J.; 7: 2335-7(Dec 1969).

Results are reported on magnetically-balanced, atmospheric, cross-flow arcs in argon. Electrodes of the pointed type were used. (M.O.W.)

## *Kinetics (Theoretical)*

*Refer also to abstract 18052.*

17921 (MATT-Trans-96) INTERACTION OF A STRONG HIGH-FREQUENCY ELECTROMAGNETIC FIELD WITH PLASMA. Silin, V. P. (Akademiya Nauk SSSR, Moscow, Institut Fiziki). Translated for Princeton Univ., N. J., from Russian report. 58p. Dep. CFSTI.

Since the free electrons of a plasma are particularly susceptible to the effect of an electric field, highly specific phenomena that occur under the effect of a strong hf field are possible in a completely ionized plasma. These phenomena turn out to be possible under conditions where the oscillation rate of the electrons becomes large by comparison with their thermal velocities. Here, the natural oscillations of the plasma turn out to be determined by an external hf field. Plasma instabilities occur that should lead to agitation of the plasma by the strong hf field. On the other hand,

under certain conditions the strong hf field has a stabilizing effect on the unstable states of the plasma. A review is presented of the theory predicting an entire series of such phenomena. (auth)

**17922** (NP-18067) STUDY OF DISCHARGE PLASMA MOVEMENTS AND THE ASSOCIATED SHOCK WAVES. Rybowski, L. (Brussels Univ. (Belgium). Faculte des Sciences Appliquees). 1969. 254p. (In French). Dep. CFSTI (U. S. Sales Only).

Thesis.

A critical comparison was made of two theoretical models describing the nonstationary movement of an intense and plane shock wave; each of the theories lead to the definition of a basic characteristic parameter k or λ, whose values differ very little. To determine the validity of one or the other model, experimental studies were made to give precise and reproducible results. Numerous modifications were made to the initial experimental assembly in order to obtain the necessary precision and reproducibility. The measurement devices were controlled statistically systematically. The most surprising result was that the movements of the plasma and of the shock wave can be made reproducible by means of certain precautions. The results led to the conclusion that the movement of the plasma does not obey a law of the homologous type and can not be considered an autosimilar movement because λ (or k) depends on the initial conditions of gas pressure and discharge energy. The movement of the shock wave, when it is divorced from that of the plasma, can be described by the homologous model and, more particularly, the value of λ corresponds remarkably with that predicted by the standard homologous solution. (tr-auth)

**17923** (ORNL-4474) REVISED FORMULATION OF THE KINETIC PLASMA THEORY. Neufeld, Jacob (Oak Ridge National Lab., Tenn.). Feb 1970. Contract W-7405-eng-26. 25p. Dep. CFSTI.

Using the Maxwellian macroscopic approach and analyzing the formulation of the dielectric constant, it is shown that the concept of energy has not been properly incorporated into the current kinetic plasma theory. The difficulties are due to the Boltzmann collisional term $(\partial F/\partial t)_{coll}$, which accounts for a change in the velocity distribution due to collisions alone. If one attempts to rephrase the Boltzmann–Vlasov theory in terms of the Maxwellian macroscopic formulation, one obtains an expression for energy which is not consistent with the meaning of this concept in generalized dynamics. In a revised version developed in this analysis the Boltzmann collisional term has been eliminated, and an appropriate collisional operator is introduced that is believed to describe collisional processes in a plasma more adequately. It is assumed that the collisional operator can be applied directly to the electrical intensity of the field interacting with the plasma and is effective in transforming the intensity in a collisionless plasma into a corresponding intensity in a collisional plasma. At the same time the relationship between the electron velocity distribution function and the field intensity is considered to be the same, whether there are collisions or not. In other words, not only a collisionless but also a collisional plasma are assumed to be controlled by a Vlasov-type mechanism that does not explicitly take into account the Boltzmann term $(\partial F/\partial t)_{coll}$. (auth)

**17924** HEAT TRANSFER, DEVELOPMENT LENGTH, AND FRICTION FACTOR CORRELATIONS FOR THE ASYMPTOTIC REGION OF A LAMINAR ARC CONSTRICTOR. Bower, W. W.; Incropera, F. P. (Purdue Univ., Lafayette, Ind.). Waerme Stoffuebertrag.; 2: No. 3, 150-62(1969).

A rigorous equilibrium model for the laminar flow of plasma through the heating region of a constricted arc plasma generator is formulated. The resulting equations are solved for an argon gas using an implicit finite-difference scheme, and the wall shear stress and heat transfer are computed from momentum and energy balances for a wide range of flow rates and arc currents. Friction factors based on this method are in agreement with empirical values to within approximately 10%, and heat transfer calculations agree with the orders of magnitude predicted by a simplified arc model. A dimensionless number peculiar to the constricted arc, the so-called ohmic heating parameter, is used to correlate the mean Nusselt numbers in the asymptotic arc regime. When the fluid properties are based on the mean temperature, the product of friction factor and Reynolds number is found to be a constant for currents below 200 A, and to vary with the ohmic heating paramoter for larger currents. Correlations are also presented for the thermal development length, and the agreement with experiment is good. (auth)

**17925** ESTIMATION OF EFFECT OF INTENSIVE MASS TRANSFER ON INTEGRAL CHARACTERISTICS OF MOVING PLASMA WITH ELECTRODYNAMIC ACCELERATION. Kolesnikov, P. M.; Stolovich, N. N. (Inst. of Heat and Mass Transfer, Minsk). Inzh.-Fiz. Zh.; 17: 1058-66(Dec 1969). (In Russian).

A system of ordinary differential equations is obtained from the Boltzmann–Vlasov equations for partially ionized plasma for description of electrodynamic plasma acceleration in integral approximation. The influence of intensive mass transfer on electrodynamic acceleration due to diffusion and rearrangement of accelerated plasma particles and increase of plasma mass caused by electrode erosion, recharging, electron adhesion to ions, and resistance and friction forces is studied. (auth)

**17926** DYNAMICS OF MULTICOMPONENT PLASMA WITH TRANSPORT PHENOMENA. Kuwabara, Sinzi (Tokyo Univ.). J. Phys. Soc. Jap.; 28: 767-75(Mar 1970).

Fundamental equations for a multicomponent plasma with transport phenomena for the case of no magnetic field are proposed. Each component of the plasma is electrically charged or neutral and has its own velocity and temperature, as well as its density and partial pressure. As the transport phenomena, the "velocity relaxations" and the "temperature relaxations" between components are taken into account, as well as the viscosities and the thermal conductivities. These fundamental equations can be confirmed on the basis of the Boltzmann equations, using the "mean free time approximation." For the typical examples, the Rayleigh- and the oscillating-plate problems for two-component plasma, etc. are examined. (auth)

**17927** ENERGY TRANSFER IN A HIGHLY IONIZED PLASMA INCLUDING COLLECTIVE AND NON-MAXWELLIAN EFFECTS. Loeinsky, Ely Simon. San Diego, Calif.; Univ. of California (1969). 111p.

Thesis.

The transfer of energy in a fully ionized Lorentz gas is first studied by considering the emission and absorption of longitudinal plasma waves between regions of the gas with near Maxwellian electron distribution functions at different local temperatures. These waves are both collision and Landau damped, with the latter type of damping effecting energy transport only secondarily, since the resulting energy is not thermalized directly. The thermal conductivity is found to agree with two-body collision treatments in the infinite Landau damping limit. The collective effects, which result from finite values of the Landau damping coefficient, contribute only a weak additional dependence to the thermal conductivity upon the plasma parameter. Next, the determination of the thermal conductivity is extended phenomenologically in the infinite Landau damping limit to include effects of electron–electron interactions. Finally, the method is generalized for a plasma with non-Maxwellian, but spherically symmetric, electron distribution functions. Sample calculations of thermal conductivity are made for modified Druyvesteyn-type electron distribution functions produced with an applied electric field. Nonlinear effects arising from the electric field induced by a temperature gradient are evaluated. (Diss. Abstr.)

**17928** FINITE GEOMETRY EFFECTS ON NONLINEAR DEVELOPMENT OF THE INTERACTION BETWEEN AN ELECTRON BEAM AND A PLASMA. Bouchoule, Andre; Weinfeld, Michel (Faculte des Sciences, Orsay, France). Compt. Rend.; Ser. B; 269: 879-82(3 Nov 1969). (In French).

Evidence is given of nonlinear phenomena observed during the evolution of an unstable electron beam–plasma system. The coupling between unstable modes on one hand and the radial variation of the distribution function of the beam energy on the other hand are phenomena intensified or introduced by the limited geometry of the medium. The latter strongly modifies the assumptions of a theory for an infinite medium concerning the saturation distances of the instabilities. (J.F.P.)

**17929** CONTRIBUTION OF THE COLLISIONS BETWEEN ELECTRONS AND NEUTRAL ATOMS TO LIGHT EMISSION AND ABSORPTION IN A PLASMA CREATED BY A LASER BEAM. Fabre, Bernard (Commissariat a l'Energie Atomique, Limeil-Brevannes, France). Compt. Rend., Ser. B; 270: 257-60(26 Jan 1970). (In French).

The bremsstrahlung and the corresponding elementary absorption were calculated, using the detailed balance principle. The radiation absorption coefficient in a slightly ionized plasma was then deduced. (France)

**17930** EFFECT OF ION MOTION ON THE COLLISIONAL CONDUCTIVITY OF A MAGNETOPLASMA. Pytte, Agnar (Dartmouth Coll., Hanover, N. H.). Phys. Fluids; 13: 767-9(Mar 1970).

The collisional contribution to the electrical conductivity is obtained for a magnetoplasma consisting of an arbitrary mixture of

charged-particle species. The calculation is based on the Landau collision term and is carried out to second order in the wavenumber. Full account is taken of the ion motion. (auth)

**17931** STABILITY OF TRANS-ALFVENIC IONIZING SHOCK WAVES. Leonard, B. P. (Columbia Univ., New York). Phys. Fluids; 13: 833-4(Mar 1970).

Unlike trans-Alfvénic shock waves in a preionized gas, trans-Alfvénic ionizing shock waves may exist. A shock wave of this type is able to stably absorb a rotational Alfvén disturbance into its structure, thereby giving rise, in general, to a perturbed "skew" shock. (auth)

**17932** SOLUTION OF FOKKER-PLANCK EQUATION FOR MIRROR-CONFINED, HOT-ELECTRON PLASMAS. Lieberman, M. A. (Univ. of California, Berkeley). Phys. Fluids; 13: 782-90(Mar 1970).

The Fokker–Planck equation describing the scattering and energy loss of hot electrons in a mirror-confined, hot-electron plasma is solved, neglecting the effect of hot-electron self-scattering, but including the effect of hot-electron scattering against neutrals, ions, and cold electrons. For a class of initial-value problems (no source), expressions for the time-asymptotic form of the distribution function f, the density n, and the mean-square velocity per contained particle $\langle v^2 \rangle$ are obtained. For a distribution function with an initial Maxwellian or Druyvestyan tail scattering against constant density neutrals, $f \sim v^\beta$ for small velocity v and large time t. For a Maxwellian tail, $\ln n \sim t^{\frac{1}{3}}$ and $\langle v^2 \rangle \sim t^{\frac{1}{3}}$; for a Druyvestyan tail, $\ln n \sim t^{\frac{1}{3}}$ and $\langle v^2 \rangle \sim t^{-\frac{1}{3}}$. Numerical calculations showing the transition to the asymptotic form of the decay are presented. For the case of steady-state injection of hot electrons, expressions for f, n, and $\langle v^2 \rangle$ are obtained in terms of the given source distribution function. (auth)

**17933** EFFECTS OF HIGH ELECTRICAL CONDUCTIVITY IN TWO-DIMENSIONAL PLASMA FLOWS. Cap, Ferdinand; Falser, Helmut (Univ. of Innsbruck). Z. Angew. Math. Phys.; 20: 947-56(25 Nov 1969).

The dissipation mechanism that causes a slippage between v and B at finite $\sigma$ is studied. A perturbation technique is used, starting from a model aligned-field solution at zero (flow with $\sigma = \infty$). It is shown that the resulting first-order system can be replaced with all consequences by only one second-order differential equation which can be transformed into an Euler–Tricomi type by a special change of independent variables. The latter is solved by integral transform methods and the conclusions are discussed for a great variety of fields $B_0(y)$. (M.O.W.)

**17934** LINE BROADENING. Cooper, J. (Univ. of Colorado, Boulder). Lect. Theor. Phys.; 11-C: 241-71(1969).

From Conference on Atomic Collision Processes, Boulder, Colo. See Conf-680842-(Pt.4).

In this lecture on broadening of spectral lines emitted by high-temperature laboratory and astrophysical plasmas, emphasis is on pressure broadening. A simple semiclassical approach in which the radiating atom is considered in terms of an equivalent oscillating dipole is outlined. The quantum autocorrelation function, from which the line shape can be obtained, is derived, and the quasi-static approximation is given. The generalized quantum mechanical impact theory is developed in detail. The line profile for an isolated line is obtained. (68 references) (A.G.W.)

**17935** DIFFUSION THEORY OF THE POSITIVE COLUMN WITH TWO-STAGE IONIZATION AND COLLISIONAL DEEXCITATION. Ingold, J. H. (General Electric Co., Cleveland). Z. Phys.; 233: 89-93(1970).

The diffusion theory of the low pressure positive column is extended to account for collisional deexcitation as well as for two-stage ionization by electron impact. This extension results in the equation $n''(\xi) + n'(\xi)/\xi + n(\xi) + \nu n^2(\xi)\,[1 + \mu n(\xi)]^{-1} = 0$, which is solved numerically for the value of $\xi_1$ which satisfies the boundary condition $n(\xi_1) = 0$ for different values of the parameters $\nu$ and $\mu$. (auth)

**17936** COLLISIONLESS FLOW OF A PLASMA MIXTURE. Lam, S. H. (Princeton Univ., N. J.). AIAA (Amer. Inst. Aeronaut. Astronaut.) J.; 7: 2094-8(Nov 1969).

The collisionless flow of a plasma consisting of two ion-species about a solid body is analyzed by extending the cold-ion theory of Lam and Greenblatt. A mixture Mach number is defined that governs the over-all behavior of the flow. The ion flux at the "ram position" of the solid body in a subsonic flow is computed, and the Prandtl–Meyer fan solution for a supersonic flow is presented. (auth)

**17937** TO THE THEORY OF INTERACTION BETWEEN A RELATIVISTIC ELECTRON BEAM AND PLASMA. Bogdankevich, L. S.; Zhelyazkov, I. I.; Rukhadze, A. A. (Lebedev Inst. of Physics, Moscow). Izv. Vyssh. Ucheb. Zaved., Radiofiz.; 13: 21-7(1970). (In Russian).

The interaction between the limited relativistic electron beam of a small density and plasma being in a strong longitudinal magnetic field is investigated. The critical plasma density, above which the electrostatic instabilities may be developed, is determined. In long enough systems, the critical density of plasma is increased with the growth of its density reaching some value determined by the directed velocity of electrons and the geometrical dimensions of the system. In the systems limited in a longitudinal direction, the critical density of plasma may be dependent also on the system length and magnetic field intensity. In this case the critical density is larger than for a long system. It follows from the analysis of the stability that the maximum current of the electron beam, which may be passed through the waveguide, increases in the relativistic region with the growth of the electron energy as $\epsilon^3$. Due to this possibility, large currents may penetrate through a dense plasma. (auth)

**17938** PLASMA LAMINATION IN A HIGH-FREQUENCY FIELD. Mironov, V. A. (Gorky State Univ., USSR). Izv. Vyssh. Ucheb. Zaved., Radiofiz.; 12: 1765-8(1969). (In Russian).

The behavior of a homogeneous plasma in a quasi-static electric field E with the frequency $\omega$ is studied. It is shown that the state of the plasma with the negative dielectric permittivity in the field larger than some critical $E_{cr}$ is unstable. As a result of the development of instability, the plasma is laminated into sections the characteristic sizes of which are estimated. (auth)

**17939** RADIATION-RESISTED MHD SHOCKS WITH VISCOSITY AND FINITE ELECTRICAL CONDUCTIVITY. Yamanaka, Tatsuo (National Aerospace Lab., Tokyo). AIAA (Amer. Inst. Aeronaut. Astronaut.) J.; 7: 1119-26(Jun 1969).

The structure of an isolated traveling shock with radiation, viscosity, thermal conductivity, finite electrical conductivity of the medium, and transverse magnetic field is treated. The boundary for partly dispersed and fully dispersed, radiation-resisted shocks is extended to the gas with transverse magnetic field. The influence of magnetic field imposed on a radiating shock is shown to make the existence of fully dispersed shocks more difficult even for the flow with low Mach numbers. Necessary and sufficient conditions for the smoothing of shocks by the mechanism of radiation energy acting alone also are extended to the same gas. The numerical results with viscosity and finite electrical conductivity have been derived. (auth)

**17940** NEGATIVE ABSORPTION BY ELECTRONS IN A MAGNETIC TRAP TYPE OF INHOMOGENEOUS MAGNETIC FIELD. Gal'tsov, D. V. Vestn. Mosk. Univ., Ser. III. Fiz. Astron.; No. 6, 27-32(Nov-Dec 1969). (In Russian).

The possibility of negative absorption in a system of electrons in a magnetic-trap type of inhomogeneous magnetic field is discussed. Calculations are given of the strength of negative absorption. (tr-auth)

**17941** WEAK CHARGED GAS BETWEEN COAXIAL ELECTRODES. Chekmarev, I. B. (Leningrad Inst. of Physics and Tech.). Zh. Tekh. Fiz.; 39: 2241-5(Dec 1969). (In Russian).

A gas of neutral and of like-charge particles between coaxial electrodes is studied theoretically, and the case of the corona discharge problem is resolved. (tr-auth)

**17942** REGIONS OF VALIDITY FOR DEBYE AND INVERSE THIRD-POWER MODELS FOR SHIELDING OF TEST CHARGES. James, C. R.; Vermeulen, F. (Univ. of Alberta, Edmonton). Can. J. Phys.; 48: 349-54(1 Feb 1970).

The shielding potential for a test charge in a plasma is derived for the case in which the velocity of the charge is much less than the thermal velocity. This potential is an analytical expression valid for any angle in space. The potential contains the Debye term and also a term which is due to the particle's motion. At large distances from the test charge the latter term asymptotically becomes proportional to the inverse third power of the distance. On the other hand, as the distance to the test charge approaches zero, this term vanishes and the potential becomes the Coulomb potential. It is shown that, although the inverse third-power term dominates at very large distances, the Debye term dominates over the very important region out to at least several Debye lengths. (auth)

**17943** EFFECT OF INELASTIC COLLISIONS ON THE TAIL OF THE ELECTRON VELOCITY DISTRIBUTION. Oxenius, J. (EURATOM-CEA, Fontenay-aux-Roses, France). Z. Naturforsch.; 25a: 101-5(Jan 1970).

The effect of inelastic electron collisions with two-level atoms, having either two bound levels or one bound level and a continuum, on the electron velocity distribution is reconsidered. Attention is paid to the role played by physical parameters like cross sections, atomic occupation numbers, and temperature. Distribution functions and collision rates are given in terms of easily accessible tabulated functions. (auth)

**17944** INFLUENCE OF ATOM–ATOM COLLISIONS ON THE POPULATION DENSITIES OF EXCITED ATOMIC LEVELS. Drawin, H. W. (EURATOM-CEA, Fontenay-aux-Roses, France). Z. Naturforsch.; 25a: 145-7(Jan 1970).

The number densities of excited hydrogen atoms in a nonthermal plasma were calculated on the basis of a coupled system of rate equations (25 levels) in which one accounts for electron–atom and atom–atom collisions. The calculated population densities depend strongly on the neutral-particle density $n_a$ when $n_e/n_a \ll 1$. When the electron temperature, $T_e$, is different from the gas temperature, $T_g$, the number densities of the excited levels are determined by $T_g$ rather than by $T_e$. This is important in connection with the quantitative spectroscopy of plasmas. (auth)

## Production

*Refer also to abstract 17876.*

**17945** (CEA-CONF–1342) LASER–MATERIAL INTERACTION ON INTENSE SOURCE OF MULTICHARGED IONS. Tonon, Gianfranco; Rabeau, Maxime (Commissariat a l'Energie Atomique, Villeneuve-Saint-Georges (France)). [1968]. 11p. (In French). (CONF-690625–7). Dep. CFSTI (U. S. Sales Only).

From International Conference on Ion Sources, Saclay, France.

It is shown that the laser–matter interaction is a source of heavy multicharged ions. From measurements made on the plasma it was established that, at strong lighting, the plasma was completely ionized and very directive, which is favorable for its utilization in a true ion source. The theoretical model adapted to this type of interaction shows the possibility of attaining high temperatures which, for iron for example, would make it possible to obtain a ratio $\langle Z \rangle / A \simeq 0.4$ with lighting already attainable in the laboratory. (tr-auth)

**17946** (CEA-CONF–1460) LASER HEATING OF SOLID-STATE TARGETS. Bobin, J. L.; Babuel-Peyrissac, J. P.; Floux, F.; Fauquignon, C.; Tonin, G. (Commissariat a l'Energie Atomique, Limeil-Brevannes (France), Centre d'Etudes). [1969]. 71p. (CONF-690825–1). Dep. CFSTI (U. S. Sales Only).

From Gordon Research Conference on Laser Interaction with Matter, Issaquah, Wash.

A theoretical model for laser interaction with solid-state deuterium is presented. Experimental results that support the theory are described. A plasma temperature varying as the power $\frac{2}{3}$ of the flux is the main result of these investigations. Other experiments deal with a beryllium target on which measurements of local densities and temperature were made and confinement of laser-created plasmas by 300-kG magnetic induction. (auth)

**17947** IONIZATION PROCESSES IN A LASER PLASMA. Afanas'ev, Yu. V.; Belenov, E. M.; Krokhin, O. N.; Poluektov, I. A. (Lebedev Inst. of Physics, Moscow). JETP Lett. (USSR) (Engl. Transl.); 10: 353-6(20 Dec 1969).

Translated from Zh. Eksp. Teor. Fiz. Pis'ma Redaktsiyu; 10: 553-7(5 Dec 1969).

A model is considered that makes it possible to calculate approximately, under strong-field conditions, such plasma parameters as the electron temperature, the ionization multiplicity, and the radiation yield. (M.O.W.)

**17948** DEVICES FOR THE PRODUCTION AND CONFINEMENT OF IONIZED GASES. Consoli, Terenzio; Dupas, Lucien; Leroy, Jean (to Commissariat a l'Energie Atomique). British Patent 1,182,298. 25 Feb 1970. Priority date 11 Mar 1966, France.

The cylindrical magnetic-mirror type of device described is of particular interest for producing plasma of high electron density and temperature, and is aimed primarily at producing a continuous flux of fusion neutrons when the ionized gases are deuterium or tritium. (M.O.W.)

**17949** APPLICATION OF Z-PINCH PREIONIZATION TO A SLOW THETA PINCH AND ITS RESULTS. Hayase, Kiyoshi; Okuda, Takayoshi (Nagoya Univ., Japan). Kakuyugo Kenkyu; 24: No. 1, 51-9(Nov 1969). (In Japanese).

The preionization by z-pinch discharge is applied to a low-energy slow theta pinch to produce a plasma at a low gas pressure and without trapping field. A pulsed current of a few tens of kA with a width of about 10 μsec is produced by condenser discharge using a nonlinear register. The characteristics of z-pinch plasma are measured with optical methods using a laser as a light source. With a peak current of 15 kA, the degree of ionization of about 60% is obtained in the low-pressure region, which is found to be suitable for the following theta compression. The temperature of the theta-pinch plasma with this preionization is consistent with that derived from a simple snow-plow model. Flute instabilities of m = 3 occurs at the pressure higher than 80 mtorr even in the case of no bias field. (NSA of Japan)

**17950** PLANE BLAST WAVE PRODUCED BY "DENSE PLASMA FOCUS". Wolf, R. J.; Nakagawa, Y. (High Altitude Observatory, Boulder, Colo.). AIAA (Amer. Inst. Aeronaut. Astronaut.) J.; 7: 1453-7(Aug 1969).

A short coaxial electromagnetic accelerator with a fast-ringing energy bank has been used to produce a hot dense plasma. This plasma in turn is collected in a small diameter tube and used as a driver gas to produce plane stable current-free high-Mach number shock fronts in the tube. These shocks closely resemble plane blast waves. (auth)

**17951** DYNAMIC GAS EFFECTS ON THE BREAKDOWN POTENTIAL FOR HELIUM, NITROGEN, AND ARGON. Gardner, J. A. (Jet Propulsion Lab., Pasadena, Calif.). AIAA (Amer. Inst. Aeronaut. Astronaut.) J.; 7: 1639-41(Aug 1969).

The effects of gas velocity and pressure on the electrical breakdown potential of He, Ar, and $N_2$ were investigated experimentally with parallel flat-plate electrodes. For He and Ar, the potential decreased suddenly with the onset of gas flow, while $N_2$ did not exhibit such behavior. Experiments on swirling and nonswirling flows of Ar between concentric, annular electrodes gave results similar to those for flat-plate electrodes. (D.L.C.)

**17952** SOURCE OF ELECTRONS IN A SELECTED ENERGY RANGE (SESER). Andrews, J. G.; Varey, R. H. (Central Electricity Generating Board, Marchwood, Eng.). Nature (London); 225: 270-1(17 Jan 1970).

A simple device is described which can provide an electron flux of several hundred amperes in the energy range up to 50 eV with a spread as low as a fraction of an eV. The device employs a constriction in a gas discharge. On the cathode side of the constriction a double sheath forms, a few Debye lengths in thickness and across which there is a potential drop of up to 50 V. Electrons are accelerated across the sheath into a highly luminous and roughly hemispherical region, known as the plasma sac, and can here be used, for example, to dissociate molecules or excite atoms. The flux can be very high since the discharge currents, which may be several hundred amperes, must all cross the sheath; it is carried chiefly by the electrons which are neutralised by ions everywhere except across the double sheath. The properties of the double sheath are described in detail. The function of the sheath is to increase the rate of ionization in the constricted region, where ions are more readily lost to the walls. In the body of the cathode plasma the electron energy distribution is approximately a displaced Maxwellian, but in the plasma sac there are two clearly defined electron groups, a high-energy group corresponding to electrons just accelerated across the sheath, and a low-energy group composed of thermalised electrons. The energy spread of the accelerated electrons is directly related to the electron temperature below the constriction, which can be controlled to some extent by altering the discharge conditions; a very effective method of lowering the temperature is to insert an auxiliary electrode which absorbs fast electrons and emits slow electrons. The appearance of a double sheath is not limited to a constriction and it may occur whenever there is a local enhancement of ion loss. Applications of SESER are described. (UK)

## Stability

*Refer also to abstract 17975.*

**17953** (COO–1478-6) MICROINSTABILITIES IN INHOMOGENEOUS PLASMA. Progress Report, May 1, 1969–January 31, 1970. Kammash, Terry (Michigan Univ., Ann Arbor). Contract AT(11-1)-1478. 10p. Dep. CFSTI.

Microinstabilities that occur in open-ended and toroidal devices and Astron were studied. The highlights of these studies are presented: (1) shear stabilization of drift waves, (2) Astron-related instabilities, (3) instabilities in finite mirror geometry, (4) convective and absolute instabilities in two-dimensional geometry, and (5) nonlinear theory and plasma turbulence. (M.O.W.)

**17954** REMARK ON THE DRIFT DISSIPATIVE INSTABILITY OF WEAKLY IONIZED PLASMA. Kopecky, V. (Inst. of Plasma Physics, Prague). Czech. J. Phys.; 20: 9-11(1970).

Ion motion along the magnetic lines is taken into account in the dispersion equation. It is shown that the drift branch of waves joins the ion-acoustic branch in the weakly ionized plasma, too, and that the term describing this motion has a stabilizing effect. These results are independent on the relation of the wavelength to the mean free path of the electrons. (auth)

**17955** CHARACTERISTICS OF MAGNETIZED PLASMA IN THE m = 1 MODE DOMAIN. Imazu, Shingo (Niigata Univ., Nagaoka, Japan); Sato, Hiroshi. Kakuyugo Kenkyu; 23: 293-300(Sep 1969). (In Japanese).

The screw instability (m = 1) of plasma associated with the anomalous diffusion of positive columns in magnetic fields was investigated. The radial potential distribution in the stationary state was calculated, using the radial density distribution reported previously. It was assumed that (1) in the positive column, the mean free paths of both electrons and ions are small compared with the tube diameter, (2) the rate of charged-particle generation is proportional to electron density, and (3) both electrons and ions have Maxwellian distribution at the constant temperature $T_-$ and $T_+$ respectively. Finite perturbation due to screw instability was assumed. Experiment was made with a tube 3 cm in diameter and 200 cm in length and containing He at 0.2 to 1.2 mm Hg. Maximum magnetic flux density was 8.0 kG. Discharge current was 50 to 200 mA. Qualitative agreement of experimental results with the calculation was obtained. Discrepancy increased with increasing magnetic field. (NSA of Japan)

**17956** SHEAR STABILIZATION OF DRIFT CYCLOTRON INSTABILITIES IN PLASMA. Davidson, James N.; Kammash, Terry (Univ. of Michigan, Ann Arbor). Phys. Fluids; 13: 721-31(Mar 1970).

Shear stabilization of low-frequency drift modes in plasma was studied intensively in recent years, but little if any work was done regarding the effect of shear on the drift cyclotron instabilities. The linearized Vlasov equations are used to examine the stability of electrostatic oscillations with frequency near integral multiples of the ion cyclotron frequency, propagating in an infinite inhomogeneous collisionless plasma situated in a sheared magnetic field. A normal mode analysis is employed to investigate the stability of waves propagating nearly normal to the magnetic field, and it is found that shear has a destabilizing effect although it does not alter the overall condition for marginal stability obtained in the uniform field case. A wave packet approach in then utilized to investigate the stability of these high-frequency oscillations when they propagate at an arbitrary angle to the field lines. For low-density plasma, it is shown that the drift cyclotron modes are stabilized by approximately the same shear required to stabilize the low-frequency modes, while at high densities, a more stringent but physically realizable shear is required for stabilization. (auth)

**17957** STUDIES OF FLUTE-LIKE INSTABILITIES IN A MAGNETOPLASMA. Emmert, Gilbert Arthur. Hoboken, N. J.; Stevens Inst. of Tech. (1969). 88p.

Thesis.

Studies of flute-like instabilities in a magnetoplasma are presented in three parts. The finite gyroradius fluid-like equations for a low-$\beta$ plasma are derived from guiding-center theory, with finite gyroradius modifications, in Part I. This derivation is simpler and physically more transparent than the original derivation of Rosenbluth and Simon. The result indicates that guiding-center theory, with finite gyroradius modifications, is applicable to low-frequency instabilities if the wavelength and characteristic lengths of the system are larger than the gyroradius. The eigenvalue equation, previously derived by Rosenbluth and Simon and by Stringer and Schmidt, describing the flute instability in the presence of a nonuniform electric field is studied in Part II. It is found that the plasma is stable if the macroscopic "drift" velocity exceeds a critical value. A necessary and sufficient condition for an instability of very long wavelength is presented. The effect of dispersion in the particle distribution function on plasma flute instability is considered in Part III. The simulation of magnetic field curvature by a gravitational field, as is usually done, ignores the possibility of resonance between the guiding-center drift and the perturbing wave. A dispersion relation that includes this effect is derived and analyzed. The growth rates and stability limits found differ from those predicted by the gravitational model. An instability due to the temperature gradient is found; it persists even for favorable (minimum B) curvature. In addition, a short-wavelength instability is found for the case of weak favorable curvature in a high-density plasma. (Diss. Abstr.)

**17958** THERMODYNAMIC STABILITY OF DENSE EQUILIBRIUM PLASMA. Seryakov, K. I. (Inst. of High Temperatures, Moscow). Teplofiz. Vys. Temp.; 7: 165-7(Jan-Feb 1969). (In Russian).

The thermodynamic properties and more specifically, the stability, of dense gaseous plasma, in which the electrostatic interaction energy of the charged particles exceeds their heat energy, have been determined earlier on the basis of the ionization equilibrium equation. A negative, concentration-dependent term in the expression indicates the instability of the system. It is considered possible that dilution of a completely dissociated plasma by neutral atoms may cause a shift of the stability boundary toward the higher electron concentrations. Calculations based on the earlier equation yielded contradictory results but in spite of this it may be concluded that the theory of T. M. Berlin and E. W. Montroll does indicate the possibility of phase transformations in a classic plasma, when the value of the interaction coefficient is relatively low. (TTT)

**17959** NOTE ON SHAFRANOV-TYPE EQUILIBRIUM CONFIGURATION OF A FINITE-$\beta$ TOROIDAL PLASMA. II. Matsuura, Kenya. Denki Shikensho Iho; 33: 1155-65(1969). (In Japanese).

The Shafranov-type equilibrium configuration in a finite-$\beta$ toroidal plasma is investigated by using the equation of the scalar stream function, which is equivalent to the well-known magneto-hydrodynamic equilibrium equations. The case in which it is assumed that the dependences of the pressure and the toroidal component of the magnetic field on the stream function are quadratic is discussed with a double-layer model. This case is considered to be the best example of the double-layer model. (auth)

**17960** NOTE ON SHAFRANOV-TYPE EQUILIBRIUM CONFIGURATION OF A FINITE-$\beta$ TOROIDAL PLASMA. I. Matsuura, Kenya. Denki Shikensho Iho; 33: 1144-54(1969). (In Japanese).

The Shafranov-type equilibrium configuration in a finite-$\beta$ toroidal plasma is investigated by using the equation of the scalar stream function $\phi$ which is equivalent to the well-known magneto-hydrodynamic equilibrium equation. The object of this note and the two subsequent notes is to search for a theoretically reasonable model of the magnetohydrodynamic equilibrium configuration inside the plasma column. The method using the equation of $\phi$ in the investigation is considered to be very useful for this object. Some introductory discussions to the investigation are given. (auth)

**17961** STABILITY OF AN INHOMOGENEOUS BEAM-PLASMA SYSTEM. Leavens, William M. (Boeing Scientific Research Labs., Seattle); Love, C. H. Phys. Fluids; 13: 732-7(Mar 1970).

The stability of realistic, inhomogeneous, plasmas with sheaths is studied by examining the interaction between an electron beam and the discrete, longitudinal, normal modes of a stable, Maxwellian plasma. A weak beam just displaces the discrete plasma eigenfrequencies in a way depending on beam current and energy. For first four eigenfrequencies $\omega$-plane maps are calculated. Instability is confined to a few intermediate modes, and growth rates are not large. (auth)

**17962** EFFECT OF TRAPPED PARTICLES ON NONAXIALLY SYMMETRIC TOROIDAL EQUILIBRIA. Dobrott, D. R.; Greene, J. M.; Johnson, J. L. (Princeton Univ., N. J.). Phys. Fluids; 13: 795-9(Mar 1970).

The effect of trapped particles on nonaxially symmetric toroidal plasma equilibria in the guiding-center limit is treated by means of the stellarator expansion. A few particles, trapped in the mirrors associated with the small-amplitude helical field, can induce an electrostatic field in a manner analogous to that which appears in the familiar treatment of nonlinear electrostatic oscillations in a one-dimensional plasma. These trapped particles directly affect the component of the current along the field and hence the final magnetic field configuration. Thus, they modify the diffusion across magnetic flux surfaces when small resistivity is introduced. (auth)

**17963** ELECTROMAGNETIC ELECTRON-ION STREAMING INSTABILITY. Ross, David W. (Univ. of Texas, Austin). Phys. Fluids; 13: 746-56(Mar 1970).

Instabilities produced by a current across a magnetic field and propagating obliquely to the field are studied in connection with the description of hydromagnetic shock waves. It is shown that there exist unstable waves of mixed polarization which can be described as coupled ion beam and whistler modes with frequencies given by $\omega \approx \mathbf{k}\cdot\mathbf{u}$ where u is the streaming velocity of the ions relative to the electrons. These waves are investigated in the small electron Larmor radius approximation and in the frequency range $\Omega_i \ll \omega \ll \Omega_e$ where $\Omega_i$ and $\Omega_e$ are the cyclotron frequencies of the ions and electrons, respectively. The maximum growth rate is limited by $\gamma < \frac{1}{2}\sqrt{3}\,(m_e u/2m_i\overline{v}_e)^{\frac{1}{3}}\Omega_e$, where $\overline{v}_e$ is the electron thermal velocity. The effect of collisions is considered, and the possibility of observing the instability in oblique shock wave experiments is discussed. (auth)

**17964** ELECTROSTATIC ELECTRON–ION STREAMING INSTABILITY. Wong, H. V. (Univ. of Texas, Austin). Phys. Fluids; 13: 757-60(Mar 1970).

When electrons drift relative to ions across a magnetic field, the field-free instabilities can still persist. However, new possibilities for collective instabilities occur. In particular, an electrostatic instability with growth rate $\gamma \sim (m_e/m_i)^{\frac{1}{3}}\Omega_e$ can develop when $\omega_{Pe} \gg \Omega_e$, $T_e > T_i$, and the electron drift velocity is less than the electron thermal velocity. This is due to the coupling of a Doppler-shifted ion mode and the electron cyclotron mode. (auth)

**17965** DYNAMIC STABILIZATION AND THE RAYLEIGH–TAYLOR INSTABILITY. Wesson, John (Los Alamos Scientific Lab., N. Mex.). Phys. Fluids; 13: 761-6(Mar 1970).

Most problems in the dynamic stabilization of plasmas have been treated in a sharp boundary limit. The stability of an incompressible liquid and of a low-$\beta$ plasma, having continuous density profiles, is considered here. The destabilizing force is gravity, and stability is sought by oscillating the system in a direction parallel to this force. In the case of a liquid, long wavelengths are stabilized but short wavelengths remain unstable. In the case of a plasma, it is found that modes that are unstable with dynamic stabilization alone or finite Larmor radius effects alone can be stabilized by the presence of both. (auth)

**17966** EQUILIBRIUM PLASMA CONFIGURATIONS IN MAGNETIC FIELDS CLOSE TO THE NEUTRAL POINT. II. Wo Kuong An. Vestn. Mosk. Univ., Ser. III. Fiz. Astron.; No. 6, 34-9(Nov-Dec 1969). (In Russian).

The problem of equilibrium configurations of a diamagnetic plasma with isotropic pressure was solved for inhomogeneous magnetic fields with complex potentials of the type $W \sim z^n$, $n = 2$. The plasma configuration geometry was determined for the case in which the plasma region does not include the neutral point (and the boundary of the region coincides with the part of the lines of force $\psi_0 \neq 0$). The cases of large and small plasma pressures are also studied. Also considered is the possibility of the transition near $\psi_0 = 0$ to the case in which plasma shifts into the neutral zone with the field $\vec{B} = 0$. The problem was resolved by the method of representations described by the author earlier (Vestn. Mosk. Univ., Ser. III. Fiz. Astron.: No. 3, 49 (1969)). (tr-auth)

**17967** EFFECT OF HALL CURRENT ON THE STABILITY OF AN ANISOTROPIC PLASMA. Kalra, G. L. (Flinders Univ., Bedford Park, Australia); Talwar, S. P. Can. J. Phys.; 48: 29-34(1 Jan 1970).

The magneto-gravitational instability of an unbounded tenuous plasma, subject to the influence of a uniform magnetic field which results in a tensorial plasma pressure, is investigated. The Chew, Goldberger, and Low equations for a collisionless plasma and a generalized Ohm's law, which includes the effects due to Hall current and electron inertia, are used. Criteria of instability in terms of plasma pressure, parallel and perpendicular to the magnetic field, and the Hall current parameter are derived for the special cases of parallel and perpendicular propagation vectors. It is found that the Hall effect has a stabilizing influence, although it does not produce stability for all wavelength perturbations. The monotonic instability is replaced by a growing wave instability (overstability). The presence of electron inertia, however, destabilizes a certain range of wavelengths which are stabilized by Hall current. (auth)

**17968** COLLECTIVE INTERACTION IN HIGH-CURRENT DISCHARGE PLASMA OF LOW DENSITY. Masud, M. M.; Maznichenko, M. E.; Reva, N. I.; Suprunenko, V. A.; Sukhomlin, E. A.; Ternopov, A. M.; Tyupa, V. I. (Inst. of Physics and Tech., Kharkov). Ukr. Fiz. Zh.; 14: 1820-4(Nov 1969). (In Russian).

The experimental results are presented concerning plasma instability occurring at the initial stage of the electrode plasma discharge when the plasma is rare. The collective processes are shown to be similar to those in case of interaction when injecting an external electron beam into plasma and differ greatly from those occuring in a plasma of high density and high rate of ionization immersed in a strong electric field. The analysis of the experimental results suggests that the collective processes might have an important influence upon the breakdown mechanism of a neutral gas. (auth)

**17969** DYNAMIC STABILIZATION OF PLASMA CYLINDER IN A LONGITUDINAL MAGNETIC FIELD. Nikulin, M. G. Zh. Tekh. Fiz.; 39: 2144-9(Dec 1969). (In Russian).

A method of small perturbations was used in studies of stability of cylindrical plasma conductors with current $I = I_0 + I_1 \cos \omega$ in a constant longitudinal magnetic field. A model of a flexible incompressible ideally conducting cylinder was used in the studies limited to the perturbations with $m = 1$. The problem was reduced to resolving the stability from the Hill equation, whose coefficients are determined by plasma and magnetic field parameters. It is shown that the use of hf current allows reduction of the longitudinal field necessary for stabilization of the cylinder, for the case in which the hf amplitude exceeded, significantly, the constant component. Optimum conditions were found for the case in which a purely ac current of sufficiently high frequency flows over the conductor. The use of the hf current may be accompanied by parametric buildup of perturbations that impose upper limits on the magnitude of the stabilizing longitudinal field. (tr-auth)

**17970** STABILITY OF OSCILLATING TRAPPED PARTICLES DURING DISTURBANCE OF QUASI-NEUTRAL PLASMA. Rosinskii, S. E.; Rukhlin, V. G. (Inst. of Physics, Moscow). Zh. Tekh. Fiz.; 39: 2136-43(Dec 1969). (In Russian).

Data obtained showed that the presence of radial electric fields appearing with the disturbance of quasineutral plasma in experimental, stellarator-type installations results in considerable changes in the trapped-particle motions which, consequently, affects plasma oscillations. The old spectra of quasi-neutral plasma oscillations in electric fields became distorted, and a new type of oscillation took place. Thus, electric fields in plasma with uncompensated charge can induce, in addition to the known instabilities in trapped particles, instabilities whose stabilization demands considerably larger fields in the installation. (R.V.J.)

**17971** STABILITY OF PLASMA IN A CORRUGATED MAGNETIC FIELD. Aleksin, V. F.; Yashin, V. I. (Inst. of Physics and Tech., Kharkov). Zh. Tekh. Fiz.; 39: 2130-5(Dec 1969). (In Russian).

Low-pressure plasma stability in a corrugated magnetic field was studied, considering convective-type perturbations ($\xi_{11} = 0$). It is shown that plasma with isotropic pressure is unstable. In case the equilibrium pressure is anisotropic, the plasma can be stable at $p_{11} - p_{\perp} > 0$. (tr-auth)

**17972** ONSET OF INSTABILITIES IN COAXIAL HALL CURRENT ACCELERATORS. Hassan, H. A.; Thompson, Charles C. (North Carolina State Univ., Raleigh). AIAA (Amer. Inst. Aeronaut. Astronaut.) J.; 7: 2300-4(Dec 1969).

An analysis is presented with the objective of predicting the onset of spokes in MPD arcs. A simple geometry consisting of coaxial electrodes with applied radial electric field and axial magnetic field is investigated with the analysis being based upon the ion and electron conservation equations. After obtaining a steady-state solution that takes into consideration the existence of anode and cathode sheaths, an $m = 1$ helical perturbation is analyzed using a normal mode analysis. The results indicate that the critical magnetic field increases with pressure, and because of the geometry chosen, it is independent of the current. The instability is of the Simon–Hoh type. (auth)

## *Thermonuclear Processes*

*Refer also to abstract 17945.*

**17973** (CEA-CONF-1386) CONVERSION OF A RADIALLY CONVERGENT BEAM WITH A LARGE DISPERSION OF ENERGY INTO A CYLINDRICAL BEAM. Becherer, Rudolf; Prevot, Francois (Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucleaires). [1969]. 12p. (In French). (CONF-690625-4). Dep. CFSTI (U. S. Sales Only).

From International Conference on Ion Sources, Saclay, France.

For the formation of a very-high-temperature plasma by injection, capture, and accumulation of accelerated particles, a radial beam with large energy dispersion ($\Delta E/E = 30\%$) was transformed into an axially cylindrical beam. This beam from an annular ion source of the magnetron type was transformed with an aid of a deflection system with inhomogeneous electrostatic field. Calculations and experiments have shown that obtaining a covergent cylindrical beam is possible and depends critically on the injection condition for the beam in the deflection system. It is also necessary that the trajectories of the ions from the source do not have an azimuthal component. This condition necessitates a compensation of the self magnetic flux of the source. The compensation of the magnetic flux was calculated, developed, and experimented on. Under typical conditions, when the initial radial beam has a length of 3 mm, a divergence of ±0.5°, and an energy dispersion of $\Delta E/E \leqq 30\%$ ($E = 15 \ldots 30$ keV), a convergent cylindrical beam is obtained. The maximum ion current obtained up to maintenance in the axial cylindrical beam at 80 cm of the median plan of the source is $I_{ion} = 70$ mA ($H_2^+$). (tr-auth)

**17974** (CEA-CONF-1387) ANNULAR SOURCE OF IONS OF THE MAGNETRON TYPE. Bariaud, Andre; Druaux, Jean; Pre-

vot, Francois (Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucleaires). [1969]. 19p. (CONF-690625-3). Dep. CFSTI (U. S. Sales Only).

From International Conference on Ion Sources, Saclay, France.

A 2.4-m annular ion source for the injection of $H_3^+$ ions for the formation of a high-temperature plasma in a magnetic mirror configuration was constructed. The source is described and illustrated. Characteristics of the ion source were determined. The experimental device and the beam adjustment for injection of the ions at the center of the magnetic configuration are discussed. The intensity of the injected beam was 300 mA instead of the 700 mA expected. The reasons for this current reduction are summarized. The pumping system is described. (J.S.R.)

17975 (LA-4351) LASL CONTROLLED THERMONUCLEAR RESEARCH PROGRAM. Status Report for 12-Month Period Ending October 1969. (Los Alamos Scientific Lab., N. Mex.). 6 Feb 1970. Contract W-7405-eng-36. 109p. Dep. CFSTI.

Recent developmental studies on z- and theta-pinch devices are reported. The studies deal mainly with stabilization and diagnostic techniques. The development of associated equipment is also reported. (M.O.W.)

17976 (MATT-759) STELLARATOR AS A NONLINEAR PLASMA CURRENT TRANSFORMER. Furth, H. P. (Princeton Univ., N. J. Plasma Physics Lab.). Feb 1970. Contract AT(30-1)-1238. 11p. Dep. CFSTI.

Oscillation of the helical winding current of a stellarator induces toroidal plasma currents proportional to the square of the winding current. (auth)

17977 (NP-18162) STUDY OF THE MAGNETIC FIELD STRUCTURE OF THE TOR-2 STELLARATOR. Ivanovskii, M. A.; Popov, S. N. (Akademiya Nauk SSSR, Moscow. Institut Fiziki). 1969. 16p. (In Russian). Dep. CFSTI (U. S. Sales Only).

The electron beam method was used in order to follow the force lines over a number of revolutions. The toroidal device is a stellarator with variable geometry of the magnetic field. The spiral two-turn field is created by a system of elliptical and circular coils. Since the existence of closed magnetic surfaces has been demonstrated, the use of an annular electrostatic probe was omitted, and data taking was limited to 10 to 20 readings of consecutive beam turns in order to determine the average angle of twist and surface shape. A point electron source is placed at a distance of 22/64 of the torus circumference from a slit tube where the detecting system is located. The detecting probe can be moved horizontally or vertically. The time of a single revolution of the electrons was about one microsecond. The radial dimension of the electron beam was less than 1 mm after one-half of a turn. The measurements were carried out at ratios R of the amplitude of the spiral harmonic to the longitudinal field that varied from 0.15 to 0.73. Magnetic surfaces are shown for R values of 0.15, 0.50 and 0.67. The experimental results were found to agree well with the calculated values of the magnetic surfaces. Some resonance field perturbations were detected and are discussed. (TTT)

17978 (UCRL-71753) MIRROR SYSTEMS: FUEL CYCLES, LOSS REDUCTION, AND ENERGY RECOVERY. Post, R. F. (California Univ., Livermore. Lawrence Radiation Lab.). 8 Sep 1969. 51p. (CONF-690901-7). Dep. CFSTI.

From International Conference on Nuclear Fusion Reactors, Culham, England.

The problem of maximizing the usable fusion energy from mirror-confined plasmas is considered. Two approaches are emphasized, as follows: (1) optimization of the fusion energy release by adjustment of the fuel plasma composition, ion temperature and operating cycle, together with exploitation of neutron-multiplying reactions in the blanket, and (2) employment of direct energy recovery techniques to improve injection efficiency and to recover energy in electrical form from the end loss particle flux. Approach (1) using DT reactions, followed by neutron multiplication and capture in sodium or aluminum is predicted to lead to steady state energy releases of about 30 to 35 MeV per reaction, depending on the tritium breeding ratio is required. With a modified DD cycle, where breeding is not required, total energy releases of about 15 MeV per deuteron should be obtainable by a similar technique. (auth)

17979 THERMONUCLEAR EXPLOSION UNDER OPTIMUM CONDITIONS. Mitra, Ved (MNR Eng. Coll., Allahabad, India). Energ. Nucl. (Milan); 17: 125-9(Feb 1970).

Considering the explosion of an H bomb, and assuming that the fusion reactions—and hence the energy yield release—take place mainly in an expanding spherical ball of isothermal D-T plasma, an expression for fractional burnup of fusion fuel is obtained. It is shown that the initial plasma size and density conditions required for a 60% burnup can be accomplished only under certain optimum conditions. (auth)

17980 A 100-kJ FAST $\theta$-PINCH DEVICE. Sugiura, Masaru; Ikeda, Nagayasu; Takeda, Shohei; Maejima, Yoshiki; Sugimoto, Hisaya; Sugisaki, Kiwamu; Hirota, Isao; Kiyama, Satoru. Denki Shikensho Iho; 33: 1124-34(1969). (In Japanese).

An experimental 100-kJ fast $\theta$-pinch device for thermonuclear fusion research was completed, and its details are reported. Main parameters of the device are as follows: (i) main compression capacitor bank: total energy, 100 kJ(at 30 kV); coil dimensions, inner diameter 11 cm, length 30 cm; maximum magnetic field, 8.35 $Wb/m^2$; maximum rise rate of magnetic field, $2.43 \times 10^8$ $Wb/m^2/s$; half period, 10.8 $\mu s$: (ii) preheat capacitor bank: total energy, 1.2 kJ (at 40 kV); frequency, 450 kHz; induced electric field, 380 V/cm: (iii) bias field capacitor bank: total energy, 30 kJ (at 5 kV); maximum magnetic field, 1.0 $Wb/m^2$, half period, 150 $\mu s$. (auth)

17981 DYNAMICS OF AN INVERSE THETATRON. Craig, A. D.; Barrault, M. R. (Univ. of Liverpool). J. Phys., D (London); 3: 387-96(Mar 1970).

A new geometry called the inverse thetatron is described in detail. The dynamics of the plasma motion are calculated using a simple momentum balance theory and measured experimentally. Preliminary results show that good symmetry and useful plasma speeds and displacement may be attained with this geometry thus alleviating the electrode problems common to other hard-core pinch geometries. (auth) (UK)

## Wave Phenomena

*Refer also to abstract 17801.*

17982 (FOA-2-2349) INVESTIGATIONS ON RESONANT NON-LINEAR WAVE INTERACTIONS IN A PLASMA. Hoeijer, Staffan; Wilhelmsson, Hans (Forsvarets Forskningsanstalt, Stockholm (Sweden)). Sep 1969. 93p. Dep. CFSTI (U. S. Sales Only).

The possibilities of nonlinear second-order mixed-frequency resonant interaction in a homogeneous, magnetoplasma were investigated. Collision effects and ion motions were not considered. A hydromagnetic approach is used, and a general case where the two primary waves propagate in arbitrary directions was treated. Possibilities of finding accurate numerical values of the resonances by a method of successive approximations are illustrated. (auth) (SWEDEN)

17983 (SC-DC-69-1720) ON THE APPROXIMATE SCATTERING CROSS SECTION OF AN ELECTRICALLY LARGE, RADIALLY INHOMOGENEOUS SPHERE. Harrison, Charles W. Jr. (Sandia Labs., Albuquerque, N. Mex.); Seshadri, S. R. (Wisconsin Univ., Madison). 12 Mar 1969. 17p. Dep. CFSTI.

The complex reflection coefficient $\Gamma$ of a planar plasma model infinite in two dimensions is used to obtain approximately the radar cross section of an electrically large radially inhomogeneous sphere. The wave impedance or generalized surface impedance concept is employed. The procedure consists of solving the Riccati differential equation for the reflection coefficient applying to the slab model using the completely arbitrary electron density-collision frequency profiles selected for the sphere. The wave impedance $Z_s$ corresponding to $\Gamma$ is calculated. The exterior boundary value problem of the sphere is then solved subject to the condition $E_{T\theta}/H_{T\phi} = -Z_s$, where E and H are the indicated components of the total electric and magnetic fields on the surface of the sphere. Only spherical Bessel and Hankel functions of integer order and real argument appear in the problem. The radar cross section of the sphere is thus expressed in terms of the reflection coefficient of the plane. The theory applies to large spheres, namely $k_0 a \geq 3$, where $k_0$ is the free space wave number and a is the radius of the sphere. The situation of greatest interest is when $k_0 a \gg 1$ and $\Gamma$ is small. The wave impedance is then $Z_s \approx \zeta_0 + j\delta$, where $\zeta_0$ is the characteristic impedance of space and $\delta$ is a small quantity. $\Gamma$ is known to be a small complex number when the electron density exponentially increases toward the center of the sphere, and the collision frequency is constant throughout the plasma profile. It is shown that the radar cross section is many orders of magnitude smaller under these circumstances than the cross section of the perfectly conducting model, i.e., $\sigma_s/\pi a^2 = 1.0$. (auth)

17984 NEGATIVE ABSORPTION NEAR THE ELECTRON CYCLOTRON HARMONICS IN WEAKLY IONIZED GASES. Idehara, Toshitaka; Nakaya, Katsuji (Fukui Univ., Japan). Fukui Daigaku Kogakubu Kenkyu Hokoku; 17: 201-11(Sep 1969).

Negative absorption of rf waves was observed near the electron cyclotron harmonics ($f = nf_c$) in weakly ionized plasma, and the

voltage gains near $f = f_c$ and $f = 2f_c$ were about 7dB and 4dB, respectively. The emissions near $f = nf_c$ ascribed to this phenomenon were observed up to n = 4 in Xe plasma, up to n = 2 in Kr plasma, and only at n = 1 in Ar plasma. Their powers were stronger by several tens dB than that of thermal noise. Frequency shift from $f = nf_c$ as a function of the electron–neutral collision frequency was measured and compared with the theoretical result where the electron distribution function was assumed to be δ-functional. (NSA of Japan)

**17985** LOW-FREQUENCY WAVES IN A POSITIVE COLUMN DISCHARGE. Aubrecht, L. (Technical Univ., Prague). Czech. J. Phys.; 20: 12-20(1970).

The propagation of longitudinal low-frequency waves in the plasma of the positive column of a dc glow discharge is studied theoretically. The dispersion characteristics are obtained for conduction, ion–acoustic and neutral–acoustic waves. Equations are solved numerically and the results are compared with other theories and measurements. (auth)

**17986** ANOMALOUS SKIN EFFECT OF MICROWAVES INCIDENT ON MAGNETO PLASMAS. Minami, Kazuo; Takeda, Susumu (Nagoya Univ., Japan). Kakuyugo Kenkyu; 23: 322-45(Oct 1969). (In Japanese).

A boundary-value problem associated with the anomalous skin effect of microwaves of angular frequency ω incident on magnetoplasma whose plasma frequency $\omega_p$ and cyclotron frequency $\omega_c$ satisfies the conditions $\omega_p \gg \omega$ and $\omega_c < \omega$ is analyzed. Method of treatment was essentially the same as that adopted by Shafranov, Weibel, and Drummond. The incident wave was supposed to be a circularly polarized plane wave. Qualitative discussion is first given to show that the longitudinal magnetic field enhances the anomalous skin effect of microwaves because the effective density and thermal velocity of the electrons increase by a factor $(1 - \omega_c/\omega^{-1})$. Possibility of experimental verification is shown by numerical calculation. The results of numerical calculations are illustrated. It is shown that attenuation of an intruding electric field is different from the exponential attenuation. (NSA of Japan)

**17987** LOW-FREQUENCY OSCILLATION IN A PLASMA PRODUCED BY LOCAL ELECTRON CYCLOTRON RESONANCE. Abe, Haruhiko; Kitagawa, Yoneyoshi (Kyoto Univ.). Kakuyugo Kenkyu; 23: 275-92(Sep 1969). (In Japanese).

A microwave coaxial plasma gun was constructed to produce and accelerate plasma by means of local electron cyclotron resonance. The instability of the plasma produced by this gun are of four types with natural frequency of about 300, 60, 10, 7 kHz. The experimental investigation of the oscillation at 7 kHz is reported, and this oscillation is interpreted as collisional current- convective instability. The frequency decreased when the length of plasma column increased. The dispersion relation is therefore, of the backward-wave type. Radial and axial distributions of electron density and temperature were also measured. The largest amplitude of the oscillation was found at a point where the radial gradient of electron density was the greatest. The rotation of the oscillation in the direction of electron diamagnetic current was found. The dispersion relation of collisional current-convective instability was calculated and compared with the observation. Qualitative agreement was obtained. (NSA of Japan)

**17988** EXPERIMENT OF THE MICROWAVE PROPAGATION IN A PLASMA ALONG THE EXTERNAL MAGNETIC FIELD. Nakamura, Sadao; Yuyama, Tetsumori (Kyoto Univ.). Kakuyugo Kenkyu; 23: 266-74(Sep 1969). (In Japanese).

The propagation of right-hand and left-hand circularly polarized microwaves in the plasma along the external magnetic field was investigated. The microwave (f = 8825 Mc) was divided into two by a magic T, and the circularly polarized wave excited by one of them was led into He plasma. For the right-hand circularly polarized wave, the reduction of propagated intensity in the magnetic field satisfying $\omega_c/\omega = 1$, where $\omega_c$ is the cyclotron frequency of electrons, was remarkable. The attenuation of the propagating wave was also measured. For the left-hand circularly polarized wave, the reduction was found at $\omega_c/\omega = 1.02$, but this was due to the reflection of the incident wave. The absorption coefficient at $\omega_c/\omega = 1$ was plotted against $(\omega_p/\omega)^2$ in the attenuation measurement for various discharge currents, and compared with the calculation. Both values showed the same tendency but were different in magnitude. The pattern of the received signal was reversed from right-hand to left-hand circular polarization by reversing the external magnetic field. (NSA of Japan)

**17989** STUDY OF MICROWAVE ABSORPTION BY PLASMA IN A MAGNETIC FIELD. Budnikov, V. N.; Golant, V. E.; Obuchov, A. A. (Ioffe Inst. of Physics and Tech., Leningrad). Phys. Lett.; 31A: 76-7(26 Jan 1970).

Data on microwave discharge formed at a magnetic field value higher than the cyclotron field (H = 1 to 3 $H_c$) and a density exceeding the critical (n = 1 to 15 $n_c$) are given. The conditions under which the discharge exists are determined by the conditions of hf wave absorption because of the linear transformation effect. (auth)

**17990** NONLINEAR BEHAVIORS OF WAVES IN A PLASMA IN THE VICINITY OF MARGINALLY STABLE STATE. Midzuno, Yukio; Watanabe, Tsuguhiro (Nagoya Univ., Japan). J. Phys. Soc. Jap.; 28: 738-47(Mar 1970).

Nonlinear behaviors of monochromatic traveling waves are discussed by the use of an asymptotic method. The wave is assumed to be stationary in the first approximation and nonlinear interactions are taken into account only among the wave under consideration and its harmonics. It is shown that two cases are distinguished according as the frequency of the wave in the first approximation is given by a simple root or a double root of the dispersion relation. Characteristic behaviors of the wave in the latter case are investigated by discussing a model equation and special cases of two-beam instability. The behaviors of the complex amplitude of the wave are visualized in the form of "a motion of a particle in an axisymmetric potential field." Various phenomena such as amplitude oscillation, explosion of amplitude, and amplitude-dependent frequency shift are found to take place depending on the plasma and the initial condition. (auth)

**17991** SUM AND DIFFERENCE FREQUENCY GENERATION IN A PLASMA BY TWO NONUNIFORM ELECTRIC FIELDS IN THE PRESENCE OF A STATIC MAGNETIC FIELD. II. Ogasawara, Masatada; Mori, Sigehiko (Keio Univ., Tokyo). J. Phys. Soc. Jap.; 28: 748-58(Mar 1970).

Boltzmann-equation analysis is made of nonlinear generation of sum and difference frequency components in the current density due to two rf electric fields applied to a magnetoplasma. Mechanism of the nonlinearity lies in nonuniform nature of the rf electric fields. All the related frequencies are assumed to be sufficiently high that dynamics of ions can be ignored. A general expression of the current density is derived both in slightly and fully ionized plasmas. Under suitable conditions, the general expression reduces to what was derived earlier by several authors. Numerical results show; (a) the nonlinear current depends much on a velocity dependence of collision frequency and (b) difference between collision frequencies $\nu_l$'s (l = 1,2) cannot be ignored. Electron–electron collision does not contribute to the nonlinear current in a magnetoplasma as in unmagnetized plasma treated by Shkarofsky. Vanishing of the contribution from the e–e collision is due to a fortuitous cancellation of the contributions from linear and nonlinear collision terms. (auth)

**17992** NONLINEAR RELAXATION OSCILLATIONS OF PLASMA IN Q MACHINES. Gurevich, A. V.; Salimov, R. A.; Buchel'nikova, N. S. (Inst. of Physics, Krasnoyarsk, USSR). Teplofiz. Vys. Temp.; 7: 1075-80(Nov-Dec 1969). (In Russian).

The mechanism of relaxation oscillations was studied. Data on excitation criteria, variation of density along the system according to the time, and the frequency of oscillations were found. The calculations were correlated with experimental data. It is shown that low-frequency oscillations were induced by the relaxation process. (tr-auth)

**17993** NOTE ON THE SYMMETRIC AND NONSYMMETRIC MODES OF BOUNDED PLASMAS. Poularikas, A. D.; Perl, A. (Univ. of Rhode Island, Kingston). Int. J. Electron.; 28: 179-83 (Feb 1970).

The dispersion relations of the two modes that can exist in a nonhomogeneous and anisotropic plasma bounded by two planes are discussed. It was found that there is qualitative agreement for both modes. In addition, a new propagating band was found at the intermediate value of the ratio $\omega_e/\omega_{p0}$. (auth) (UK)

**17994** OPTIMUM HARMONIC GENERATION IN PLASMAS. Sodha, M. S.; Sawhney, B. K.; Sawhney, R. L. (Indian Inst. of Tech., New Delhi). J. Phys., D (London); 3: 377-86(Mar 1970).

Using the expressions for the second and third harmonic components of the current density in a plasma, subjected to an external alternating field and a dc electric field, the conditions were investigated for maximum efficiency of harmonic generation in a plasma. It is concluded that (i) the intensity of harmonics is higher in the transmitted component than in the reflected component from a plasma slab, and that (ii) the efficiency of second-harmonic conversion is maximum when $0.80 < (\omega_p/\omega)^2 < 0.90$ and dimensionless plasma thickness ($\xi_0 = \omega z/c$) in the range $3.20 < \xi_0 < 3.50$ and the efficiency of the third-harmonic generation is a maximum when $0.80 < (\omega_p/\omega)^2 < 0.95$ and $2.50 < \xi_0 < 3.40$. The variation of the efficiencies in these limits is not significant. (auth) (UK)

**17995** PROPAGATION OF OBLIQUE E WAVES IN A WARM PLANE STRATIFIED PLASMA. Tang, Ting-wei (Univ. of Massachusetts, Amherst). Radio Sci.; 5: 111-19(Jan 1970).

The propagation of an oblique E-mode electromagnetic wave in a plane stratified collision-free plasma is investigated. A singularity associated with the electric field near the plasma resonance is shown to disappear when the effect of the finite temperature of the plasma is taken into account. By allowing for a weak spatial dispersion, a fourth-order warm-plasma field equation is obtained, and a connection formula based on an analytical continuation of integral solutions is deduced. The connection formula is then applied to the problem of mode coupling between electromagnetic E waves and electrostatic plasma waves. (auth)

17996 AMPLITUDE MODULATION OF MICROWAVES PROPAGATED THROUGH A PERIODICALLY VARYING PLASMA. John, P. I.; Sarkar, D. C. (Aligarh Muslim Univ., India). Radio Sci.; 5: 101-9(Jan 1970).

A theory is developed for the amplitude modulation of microwave signals propagated through a plasma created by an amplitude-modulated rf field by taking into account the variations in the electron density and the electron–molecule collision frequency of the plasma due to the modulation of the electron temperature. Experimental studies verified the predicted dependence of the microwave modulation index on the modulation frequency, the exciting field strength, and the carrier modulation index. Slight deviations are found between the experimental and theoretical values at both very low and very high modulation frequencies. The dependence of the rf conductivity on the exciting field is suggested as the probable cause for the departures of the experimental values from the theoretical ones. (auth)

17997 NON-LINEAR FLUCTUATIONS IN NON-EQUILIBRIUM PLASMA. Radzievskii, V. N. (Inst. of Physics, Kiev). Ukr. Fiz. Zh.; 14: 1988-97(Dec 1969). (In Russian).

The problem of nonequilibrium fluctuations of the scalar potential in plasma being at a quasi-stationary state near the stability region boundary is considered, taking into account effects of the nonlinear interaction between the branches of natural oscillations. A system of approximate integral equations is obtained for the potential spectral function. In the particular case of a quasi-unidimensional spectrum, this system is solved and approximate expressions are found for spectral densities of the Langmuir and ion–acoustic fluctuations. (auth)

17998 DIFFRACTION OF CYLINDRICAL WAVES ON THE IMPEDANCE WEDGE IN AN ANISOTROPIC PLASMA. Bobrovnikov, M. S. Izv. Vyssh. Ucheb. Zaved., Fiz.; No. 11, 119-22(1968). (In Russian).

The properties of cylindrical electromagnetic waves are examined, considering cases in which the wave is incident on the impedance edge in a homogeneous anisotropic plasma, in a direction parallel with that of a constant magnetic field; one of the axes of the cylindrical coordinate system coincides with the height of the wedge. The impedance boundary conditions prevail at the limits of the wedge. As a result of the geometry of the system, only TM waves are generated. The searched-for field must also satisfy the condition of finiteness. The solution consists of a double integral in the plane of the complex variable. Because of the large number of figures involved, the actual calculated values are not presented. An expression was obtained for the excitation of an impedance wedge at the top of the linear source in the anisotropic plasma. When the source is at infinity, the diffraction of plane, homogeneous surface waves on the impedance wedge in the anisotropic plasma is determined. The expression may be generalized for the two-dimensional problem in both isotropic and anisotropic media. (TTT)

17999 DRIFT-WAVE FLUCTUATIONS AND ANOMALOUS DIFFUSION IN A FULLY IONIZED CESIUM PLASMA. Walsh, John Edmond Ivers. New York; Columbia Univ. (1969). 143p. Thesis.

The diffusion of a fully ionized plasma across a magnetic field is related to the experimentally determined properties of the density fluctuations in a single-ended Q Machine. A Cs plasma with a density $N_0 = 3 \times 10^{10}$ cm$^{-3}$, temperature ~2300° magnetic field ~3KG with ion sheaths at the end plates was used. Under these conditions a broad spectrum of low-frequency fluctuations with very little discrete content was observed. A phenomenological model for the fluctuations based on the properties of drift waves and which takes into account the anomalous diffusion caused by the waves is introduced and is used to associate the measured fluctuations with a continuous spectrum of drift waves. The fluctuations are studied with both spectral and correlation techniques. A measurement of the correlation function, $c(\tau) = \langle \delta n(t)\ \delta n(t+\tau) \rangle$, which is determined from the fluctuating component of the ion saturation current drawn to a double Langmuir probe yields the mean square fluctuation $\langle \delta n^2 \rangle$ is proportional to $v_D^2$, the square of the diamagnetic drift velocity minus the drift caused by a dc radial electric field. There is semi quantitative agreement between the model which predicts the coefficients of these proportionalities and these experimental results. A measured effective diffusion coefficient $D_\perp$ is compared with the measured fluctuations $\langle \delta n^2 \rangle$. We find $D_\perp \sim \langle \delta n^2 \rangle$ for small $\langle \delta n^2 \rangle$ and $D_\perp \sim \langle \delta n \rangle^4$ for large $\langle \delta n^2 \rangle$. These results which are consistent with the phenomenological model are also in agreement with the nonlinear diffusion theory of Dupree. (Diss. Abstr.)

18000 ON ANOMALOUS TRANSFORMATION OF WAVES IN AN INHOMOGENEOUS PLASMA. Erokhin, N. S. (Inst. of Physics and Tech., Kharkov). Ukr. Fiz. Zh.; 14: 2059-66(Dec 1969). (In Russian).

The transformation of a long- and short-wave mode is considered in the resonant layer of an inhomogeneous plasma when the long-wave mode has one turning point. The exact solution is found. It is shown that the turning point can decrease essentially the efficiency of transformation if the distance between the turning point and resonant layer is of the wavelength order. (auth)

18001 DISPERSION RELATION FOR COMPUTER-SIMULATED PLASMAS. Lindman, E. L. (Austin Research Associates, Tex.). J. Comput. Phys.; 5: 13-22(Feb 1970).

A dispersion relation for a computer-simulated plasma in which the effects of discreteness in space and time are treated exactly is derived. In the limit that the mesh spacing and the time step go to zero independently, the well-known results associated with a collisionless plasma are obtained. Nonphysical Landau damping of a wave by particles traveling at phase velocities associated with frequency "aliases" and numerical dispersion associated with a finite time step are easily avoided with small-enough time steps. Discreteness in space plus interpolation between mesh points leads to modes that can be represented as sums of backward and forward traveling sinusoidal waves. The total resonant interaction of the particles with a mode is the sum of their interactions with each of the components. For a Maxwellian distribution, the forward traveling components lead to damping, but the backward traveling components lead to growth. Consequently, numerically unstable modes can occur in a Maxwellian plasma. (auth)

18002 PARAMETRIC MODE–MODE COUPLING BETWEEN DRIFT WAVES IN PLASMAS. Hai, Francis; Wong, Alfred Y. (Univ. of California, Los Angeles). Phys. Fluids; 13: 672-86 (Mar 1970).

The nonlinear phenomenon of parametric excitation of stable resonant drift modes through mode–mode coupling is examined in the potassium plasma of a Q device. The scheme, which was extensively investigated, is the degenerate case of three-mode parametric coupling in which the stable resonant mode (m = 1) at $\omega_1$ is excited by the externally driven pump mode (m = 2) at $\omega_0 = 2\omega_1$. The usual frequency and wavenumber matching conditions are satisfied. The additional new aspects examined are the enhancement of thermal fluctuations, the threshold for excitation, and the power balance between the coupled modes and the external source. The main results obtained are the measurement of the coupling coefficient and the determination of the functional behavior of the modes. General agreement between the experimental results and theory derived from the expansion of the governing fluid equations to second order is attained. To describe the steady-state amplitudes observed experimentally, nonlinear saturation phenomena are included. Nondegenerate and higher-order coupling schemes are briefly considered. Parametric coupling as a mechanism limiting the amplitude of an unstable mode and leading to a turbulent plasma is presented and discussed. The modification of the linear stability of a lower mode due to mode coupling from a higher mode is illustrated. (auth)

18003 CONVECTION ARISING FROM LARGE-AMPLITUDE PLASMA WAVES. Chen, Francis F.; Etievant, C. (Princeton Univ., N. J.). Phys. Fluids; 13: 687-93(Mar 1970).

It is found that large-amplitude plasma waves can cause dc particle drifts which can have a deleterious effect on plasma confinement during rf heating. A standing wave in an inhomogeneous plasma is likely to cause convective cells with a periodicity equal to half the wavelength of the wave. As examples, ordinary and extraordinary electromagnetic waves and ion cyclotron waves are chosen for detailed treatment. (auth)

18004 COLLISIONAL DRIFT WAVES IN THE LINEAR REGIME. Rowberg, Richard E.; Wong, Alfred Y. (Univ. of California, Los Angeles). Phys. Fluids; 13: 661-71(Mar 1970).

A method of external excitation of density gradient drift waves in a stable, collision-dominated plasma is presented whereby the linear theory of drift waves is verified. The procedure permits limitation of the perturbation amplitude such that $e\phi_1/kT < 0.1$. This represents a new approach in the study of drift waves since nonlinear saturation effects present in all previous experiments on

these waves are avoided. The driven oscillations are coherent, nearly sinusoidal modes on which measurements of $\omega$ and k as a function of the plasma parameters are made. In this manner the linear dispersion relation derived from the fluid equations is verified demonstrating the strong stabilizing effect of transverse diffusion resulting from ion viscosity. In connection with this an additional damping process resulting from ion loss at the cathodes is introduced whereby complete stabilization of the plasma to drift waves is possible. Next, the functional dependence of the phase angle between the density and potential perturbation is shown and correlation between the phase angle and the growth rate is discussed. Finally, verification of the dependence of the axial wavelength on the sheath conditions at the plasma cathode boundary and on the length of the plasma column is demonstrated. (auth)

18005 NONLINEAR LANDAU DAMPING: THE SPECTRUM. Eldridge, Owen (Univ. of Tennessee, Knoxville. Oak Ridge National Lab., Tenn.). Phys. Fluids; 13: 738-45(Mar 1970).

The spatial damping of large-amplitude electrostatic waves in a collisionless plasma is derived. The theory leads to differential equations which describe the nonlinear oscillation of the electric field amplitude, the broadening of the frequency spectrum, and the growth of sidebands. When driven at a single frequency the sidebands are displaced by a frequency $\pm 0.8\Omega = \pm 0.8(e\kappa E_0/m)^{\frac{1}{2}}$, where e and m are the electron charge and mass, $\kappa$ is the wavenumber, and $E_0$ is the amplitude of the electric field. The sidebands oscillate in space with a periodicity $L = (2\pi/0.8\Omega)(d\omega/d\kappa)$. The upper sideband is suppressed by linear Landau damping for large amplitudes. (auth)

18006 ION CYCLOTRON WAVE GENERATION IN THE MODEL C STELLARATOR. Hosea, J. C.; Sinclair, R. M. (Princeton Univ., N. J.). Phys. Fluids; 13: 701-11(Mar 1970).

To permit quantitative comparisons between experiment and theory, ion cyclotron wave generation by the Stix coil system of the Model C stellarator is analyzed, using a coil-plasma model which closely approximates the physical system: filamentary currents at the coil loop positions induce plasma waves which propagate along the "cold" plasma column which is coaxial with a cylindrical waveguide. Most important in the analysis is the inclusion of finite electron inertia effects which cause the natural modes of the system to be characterized by two radial wavenumbers in place of one and which can seriously modify the properties of the ion cyclotron waves. Coil loading predictions are in good absolute agreement with experimental observations for wide ranges of plasma density and magnetic field, thus demonstrating the relevance of the cold theory to the laboratory plasma. However, magnetic field predictions are larger than the fields measured far from the Stix coil, suggesting wave attenuation by processes not contained in the theory. (auth)

18007 NONLINEAR ION-ACOUSTIC WAVES IN A VLASOV PLASMA. Gary, S. Peter (Univ. of St. Andrews, Fife, Scotland). Phys. Fluids; 13: 694-700(Mar 1970).

Nonlinear ion-acoustic waves in a collisionless, Maxwellian, electron-ion plasma are considered in an initial-value problem. The changes in the secondary order, spatially homogeneous parts of the distribution functions are calculated in the long time limit, and are used to modify the linear dielectric function. For $T_i \sim T_e$, it is shown that nonlinear electron contributions are much more important than corresponding ion terms, and the zero electron mass approximation is not valid for calculating nonlinear damping in this case. The decrease in the magnitude of the damping decrement in the long time limit is obtained. (auth)

18008 GRID EXCITATION OF ION WAVES AT FREQUENCIES ABOVE THE ION PLASMA FREQUENCY. Doucet, H. J.; Gresillon, D. (Ecole Polytechnique, Paris). Phys. Fluids; 13: 773-81(Mar 1970).

The excitation of ion waves is discussed on the basis of a classical model and experimdntally studied in a cesium plasma produced in a single-ended Q machine, when a small voltage is applied on a grid immersed in the plasma. For frequencies smaller than the ion plasma frequency $f_{pi}$, an ion-acoustic wave is observed which is consistent with the predictions of the classical linear kinetic theory for a Maxwellian plasma. For higher frequencies ($f \gtrsim f_{pi}$) two components are observed: the ion-acoustic wave, which propagates for frequencies higher than the ion plasma frequency and a faster signal, called a "pseudowave," which is in satisfactory agreement with the ballistic linear contribution of ions to the voltage perturbation in the plasma. (auth)

18009 DISPERSION RELATION FOR TRANSVERSE WAVES IN A RELATIVISTIC PLASMA. Gupta, R. M.; Varma, N. L. (Univ. of Rajasthan, Jaipur, India). Curr. Sci. (India); 39: 107 (5 Mar 1970).

Dispersion relations are derived using the relativistic Vlasov equation. An outline of the derivation is given. (M.O.W.)

18010 EXPERIMENTAL AND THEORETICAL STUDIES OF ELECTROTHERMAL WAVES. Gilpin, Robert R.; Zukoski, Edward E. (California Inst. of Tech., Pasadena). AIAA (Amer. Inst. Aeronaut. Astronaut.) J.; 7: 1438-45(Aug 1969).

Experimental and theoretical studies have been made of the electrothermal waves occurring in nonequilibrium electrical discharges in a potassium-seeded argon plasma in transverse gas flow and magnetic field. The behavior of these discharges as determined by photographs, photomultiplier measurements, and voltage probes is discussed and the results interpreted in terms of a steady, one-dimensional theory. A single discharge was found to operate in one of three modes-the shorted, transition, or normal mode-depending on the length of the ionization transient. An extension of the one-dimensional theory to the inlet problem predicts the approximate length of this transient and thus provides criteria for the existence of each mode. The normal mode was studied in a duct with a series of circuits discharging in parallel across a gas flow. Here, a regular set of steady, one-dimensional streamers was found in the center of the duct between hot boundary regions along each electrode wall. The properties of the one-dimensional streamers are shown to agree in detail with values predicted from the one-dimensional theory. A scheme is then presented for calculation of the effective conductivity of a duct using the amplitude of conductivity fluctuations predicted by this theory. (auth)

18011 WAVEGUIDE MODES OF A WARM DRIFTING UNIAXIAL ELECTRON PLASMA. Kalluri, Dikshitulu (Wichita State Univ., Kan.). Proc. IEEE (Inst. Elec. Electron. Eng.); 58: 278-80(Feb 1970).

The dispersion relation for guided waves in warm drifting uniaxial electron plasma is derived. The phase characteristics of the "fast," "slow," and "waveguide" waves are discussed and presented as graphs with the normalized empty guide cutoff frequency as the parameter. (auth)

18012 RESONANCE EXCITATION OF ION CYCLOTRON OSCILLATIONS IN PLASMA PLACED IN THE CROSSED ELECTRIC AND MAGNETIC FIELDS. Rozhkov, A. M.; Stepanov, K. N.; Suprunenko, V. A.; Farenik, V. I.; Vlasov, V. V. (Kharkov State Univ. Inst. of Physics and Tech., Kharkov). Ukr. Fiz. Zh.; 14: 1856-61(Nov 1969). (In Russian).

The resonance excitation is studied of ion-cyclotron oscillations in plasma, which is in the crossed electric and magnetic fields. It is shown by the experiment that the frequency of drift rotation of ion flow for the given value of the magnetic field being divisible by the frequency of ion-cyclotron oscillations, the resonance cyclotron instability develops in plasma. This instability is followed by mighty superheat emission at the frequency close to gyrofrequency of ions and essential heating of the plasma ion component. Increment of the given instability is of the ion cyclotron frequency order. (auth)

18013 INTENSE ABSORPTION OF ELECTROMAGNETIC RADIATION IN INHOMOGENEOUS COLLISIONLESS PLASMA. Davydovskii, V. Ya.; Yakushev, E. M. (Inst. of Nuclear Physics, Alma-Ata, USSR). Zh. Tekh. Fiz.; 39: 2236-8(Dec 1969). (In Russian).

Studies of intense absorption of electromagnetic radiation in inhomogeneous collisionless plasma showed that waves in the optical range ($\omega \sim 10^{15}$ sec$^{-1}$) were captured as effectively by particles as radio waves ($\omega \sim 10^{10}$ to $10^{8}$ sec$^{-1}$) for cases in which their intensity exceeds the radio emission by $10^{10}$ to $10^{20}$. (R.V.J.)

18014 NONLINEAR INTERACTIONS OF SURFACE WAVES IN NONISOTHERMAL PLASMA. Kondratenko, A. N.; Shaptala, V. G. (Inst. of Physics and Tech., Kharkov). Zh. Tekh. Fiz.; 39: 2229-31(Dec 1969). (In Russian).

The problem of nonlinear interactions of surface waves in nonisothermal semiconfined plasma was studied. Inhomogeneous boundary conditions were found by use of the plasma-vacuum sharp-boundary model. The observed inhomogeneity was induced by nonlinear surface currents. Coupling coefficients and increments of excitation were found for arbitrary angles between the direction of propagation of the fundamental high-frequency and excited low-frequency waves. (tr-auth)

18015 INCOHERENT SCATTERING OF ELECTROMAGNETIC WAVES IN WAVEGUIDE WITH PLASMA. Yakimenko, I. P. (Inst. of Radioelectronics, Kharkov). Zh. Tekh. Fiz.; 39: 2163-8 (Dec 1969). (In Russian).

The general theory of electromagnetic fluctuations and the reciprocity theorem were used for determining cross sections for electromagnetic-wave scattering from electron charge density fluctuations in a rectangular waveguide with isotropic plasma.

Various processes of wave transformation during scattering from the fluctuations were examined. (tr-auth)

# Shielding

*Refer also to abstracts 18320 and 18754.*

18016 . (BMBW-FBK-69-43) DP1: AN ALGOL PROGRAM FOR THE COMPUTATION OF ENERGY SPECTRA OF SCATTERED GAMMA RAYS IN A FINITE SLAB SHIELD. Gerstl, S. A. W. (Karlsruhe Univ. (West Germany). Institut fuer Struktur der Materie). Dec 1969. 36p. (In German). Dep. CFSTI (U. S. Sales Only). ZAED.

The ALGOL-program DP1 solves the equations of the double-$P_1$-approximation for the transport equation, which depends on space, angle and energy, in slab geometry for $\gamma$-rays. This report gives a summarized description of the formalism of the solutions and finishes with the listing of the complete ALGOL-program. The main aim of the report is the specification of input and output data. A detailed discussion is devoted to the numerical integration, which uses a generalized Simpson rule with nonequal integration steps for integrands with two discontinuities. The approach used, permits the explicit analytical formulation of the final result and could also serve as a first step towards a generalization to higher $DP_L$-approximations. (auth)

# Solid-State Physics

*Refer also to abstracts 17257 and 18097.*

## Radiation Effects

*Refer also to abstracts 16545 and 16568.*

18017 (ANL-Trans-810) LUMINESCENCE OF LiF CRYSTALS BY EXCITATION FROM REACTOR RADIATION. Shvarts, K. K.; Podin, A. V.; Aluker, E. D.; Itenberg, L. E. Translated for Argonne National Lab., Ill., from Latv. PSR Zinat. Akad. Vestis, Fiz. Teh. Zinat. Ser.; No. 5, 30-5(1968). 9p. Dep. CFSTI.

The radioluminescence and thermoluminescence of various LiF crystals were investigated upon excitation by unfiltered and filtered (1 mm cadmium) radiation of the reactor. The efficiency of radioluminescence of all the investigated crystals drops sharply in the temperature region of stabilization of $V_k$ centers. Upon excitation by filtered reactor radiation the efficiency of radioluminescence and thermoluminescence per absorbed unit dose is considerably higher. This is related to the influence of the density of the exciting radiation. (auth)

18018 HIGH-DOSE IMPLANTATIONS OF P, As, AND Sb IN SILICON: A COMPARISON OF ROOM-TEMPERATURE IMPLANTATIONS FOLLOWED BY A 550°C ANNEAL AND IMPLANTATIONS CONDUCTED AT 600°C. Crowder, Billy L. (International Business Machines Corp., Yorktown Heights, N. Y.); Fairfield, John M. J. Electrochem. Soc.; 117: 363-7(Mar 1970).

A study was made of room-temperature implantations of large doses of P, As, and Sb into Si substrates, followed by annealing in the temperature range 550 to 600°C and of implantations of these species into Si substrates maintained at 600°C. Neutron activation combined with anodic oxidation and HF stripping techniques was used to determine the profiles of the implanted ions. Electrical evaluation of the implanted layers by Hall effect and sheet resistivity measurements in conjunction with anodic oxidation and HF stripping techniques yielded profiles of the net electrically active species. The profiles obtained for 600°C implantations are markedly orientation-dependent since the crystalline nature of the Si lattice is maintained during the implantation. Most of the P, As, or Sb ions implanted at room temperature are electrically active after annealing at 550 to 600°C, and the carrier mobility observed in the implanted layer approaches that obeerved in comparably doped bulk Si. Only a small fraction of the ions implanted at 600°C are electrically active and uncompensated, and the carrier mobility in these layers reflects the increased scattering due to charged compensating defects. (auth)

18019 · LOW-TEMPERATURE ELECTRON IRRADIATION OF SILICON CONTAINING CARBON. Bean, A. R.; Newman, R. C. (Univ. of Reading, Eng.). Solid State Commun.; 8: 175-7(1 Feb 1970).

Previous work has shown that irradiation of silicon at low temperatures leads to the formation of a center giving rise to local mode absorption bands at 922 and 932 $cm^{-1}$; this center has been ascribed to a carbon–oxygen complex with a trapped silicon interstitial in an adjacent site. It has now been established that these bands can also be produced in oxygen-free crystals and analogous bands at 892 and 904 $cm^{-1}$ are formed when $^{13}C$ is present. It is deduced that this center probably arises from an interstitial carbon atom in a site of axial symmetry. (auth) (UK)

18020 ON VACANCY CLUSTERS IN NEUTRON-IRRADIATED NICKEL AT LOW TEMPERATURE. Bourret, A. (CEN, Grenoble, France); Levelut, A. M. Phys. Status Solidi; 37: K101-3 (1 Feb 1970).

X-ray small-angle scattering was performed on Ni after neutron irradiation ($4 \times 10^{18}$ nvt > 1 MeV) at 77°K and different anneals. The intensities are one order of magnitude smaller than that expected if the vacancy-type defects are voids. It is concluded that the defects are probably stacking-fault tetrahedra. (D.L.C.)

18021 INFRARED ABSORPTION OF THE $FCl^-$ HETERONUCLEAR MOLECULE ION IN KCl. Susman, S. (Argonne National Lab., Ill.). Phys. Status Solidi; 37: 561-70(1 Feb 1970).

Single crystals of KCl doped with KF and exposed to high dosages of $^{60}Co$ $\gamma$ radiation develop a simple doublet absorption on the high-frequency edge of the KCl reststrahl. This 403.7 – 399.8 $cm^{-1}$ doublet is assigned to the fundamental internal vibration of the $FCl^-$ heteronuclear molecule ion. The doublet separation, intensity ratio, thermal decay, optical bleaching, and polarization properties support this assignment. The internal stretching frequency of $FCl^-$ in KCl is not markedly different than would be approximated from gas phase data for the neutral species. (auth)

18022 ANALYSIS OF DEFECT ANNEALING IN MONOCRYSTALLINE GOLD FOILS AFTER GOLD ION IRRADIATION. Wittmaack, K. (Univ., Munich). Phys. Status Solidi, 37: 633-45(1 Feb 1970).

Monocrystalline gold foils were irradiated at −196°C with gold ions parallel to [101] or at random incidence. Defect production and subsequent isochronal recovery between −180 and 40°C were examined by means of the electrical resistance for energies from 5 to 30 keV and doses from $5 \times 10^{12}$ to $5 \times 10^{15}$ ions/$cm^2$. The annealing spectra are characterized by an intense dose-dependent peak between −40 and −25°C which is interpreted as being due to the recombination of freely migrating interstitials ($E_I^M$ = (0.77 ± 0.07) eV) with vacancies. After high-dose preirradiation and subsequent annealing, the recovery in the dominant peak is reduced in favor of a new peak appearing between 0 and 40°C. This is explained in terms of a migration of vacancies to defect clusters. (auth)

18023 ELECTRON ENERGY LOSS AND F-CENTRE PRODUCTION IN KCl AND KBr. Choudhury, A.; Goswami, K.; Chaudhuri, S. (Jadavpur Univ., Calcutta). Phys. Status Solidi; 37: 865-8 (1 Feb 1970).

A rotating cylindrical crystal of KCl was bombarded by 19-keV electrons and the F-center distribution observed as a function of the angle of rotation. Eight maxima were found corresponding to different angular positions of the crystal. The depth of coloration was measured along the ⟨100⟩ and ⟨110⟩ axes in KCl and KBr crystals. In both crystals, the magnitude of coloration was higher along ⟨110⟩ axes than along ⟨100⟩ axes, but the depth of coloration or the electron range had been found to be longer along the latter direction. The results are interpreted in terms of channeling effect. (auth)

18024 OPTICALLY PRODUCED THERMOLUMINESCENCE GLOW PEAKS IN FLUORITE. Sunta, C. M. (Bhabha Atomic Research Centre, Bombay). Phys. Status Solidi; 37: K81-3 (1 Feb 1970).

The origin of optically produced glow peaks in natural fluorite was studied. After exposure to x or $\gamma$ rays and heating up to 400°C to bleach out the TL peaks I to IV (leaving V unaffected), uv irradiation of the cooled sample results in regeneration of the peaks I to IV. The effects of wavelength on this regeneration effect were studied. The effects of filtered Hg light ($\lambda$ > 5000 Å) on a sample with a strong residual peak III were determined. It is concluded that the optical regeneration of glow peaks is due to redistribution of optically released carriers from residual traps into other traps. (D.L.C.)

18025 DEPENDENCE OF THE SPUTTERING YIELD ON FOCUSSING CHAINLENGTH. Dey, S. D.; Basu, D.; Karmohapatro, S. B. (Saha Inst. of Nuclear Physics, Calcutta). Nucl. Instrum. Methods; 77: 242-4(1970).

Sputtering yield of a silver (110) single crystal due to bombardment by normally incident singly charged ions of zinc and cadmium in the energy range 5 to 35 keV is measured and the results are fitted to the values calculated on the basis of the Onderdelinden's model with $X_0$, equal to 65 Å, the depth below the silver surface responsible for sputtering. The results suggest the dependence of the sputtering yield on focusing collision chain length. (auth)

**18026** HALL EFFECT MEASUREMENTS ON Sb- AND Ga-IMPLANTED SILICON; ANNEAL BEHAVIOR AND COMPARISON WITH OTHER SPECIES. Johansson, N. G. E.; Mayer, J. W. (California Inst. of Tech., Pasadena). Contract F61052-68-C-0062. Solid-State Electron.; 13: 123-30(Feb 1970).

Analyses of n- and p-type silicon samples implanted with 50-keV Ga and 40-keV Sb ions at substrate temperatures of 350°C and room temperature were made by use of Hall effect and sheet resistivity measurements. It was found that the presence of an amorphous layer formed during implantation has a major effect on the anneal characteristics. For Sb and Ga samples implanted at room temperature to doses $\gtrsim 10^{14}/cm^2$, a large increase in the number of carriers per $cm^2$, $N_s$, was observed after anneal at temperatures of ≈550°C. The maximum value of $N_s$ was found for anneal temperatures of 550–600°C. This temperature corresponds to the reordering of an amorphous layer as observed in channeling effect measurements. At an anneal temperature of 900°C, the concentration of carriers/$cm^3$ exceeded the thermal equilibrium solubility value for Sb implantations and was comparable to this value for Ga. In both high-dose ($\approx 2 \times 10^{14}/cm^2$) 350°C and low-dose ($\approx 10^{13}/cm^2$) room-temperature implantations of both species, the anneal behavior was similar; here anneal temperatures of ≈800°C were required to obtain the maximum value of $N_s$ and no anneal stage was observed at 550°C. (auth) (UK)

**18027** IMPLANTED PROFILES OF BORON, PHOSPHORUS, AND ARSENIC IN SILICON FROM JUNCTION DEPTH MEASUREMENTS. Davies, D. Eirug (Ion Physics Corp., Burlington, Mass.). Solid-State Electron.; 13: 229-37(Feb 1970).

The junction depth technique has been used to investigate the profiles of boron, phosphorus, and arsenic implanted into silicon over the energy region of 0.1 to 2.0 MeV and at the dose level of $10^{15}$ $cm^{-2}$. The range observed for boron is considerably less than that found in independent measurements with low dose implants. A movement towards the silicon surface of the ions in the more heavily damaged region during annealing is suggested. Both phosphorus and arsenic show a range that agrees with low dose determinations; for arsenic the experimental range also agrees with theory, while in the case of phosphorus it is only about 75% of the calculated unprojected range. The phosphorus and arsenic profiles exhibit an exponential tailing which is not eliminated by pre-implant damage and is therefore not considered to be caused by channeling. On the surface side of the range, all three ions exhibit a very gradual concentration fall-off that often prevents the shallower of the expected junction pairs from being observed. (auth) (UK)

**18028** ANNEALING BEHAVIOR OF PHOSPHORUS-DOPED GERMANIUM IRRADIATED BY ELECTRONS AT 77°K. Jeong, Manu; Inuishi, Yoshio (Osaka Univ.). Technol. Rep. Osaka Univ.; 19: 563-9(Oct 1969).

Annealing of the reciprocal mobility and carrier concentrations in phosphorus-doped germanium irradiated by 1.5-MeV electrons at 77°K has been investigated by an isochronal annealing technique. Annealing stages at about 120, 280, 350 and 460°K, are observed. The results are compared with those obtained on antimony- and arsenic-doped germanium irradiated by $^{60}Co$ gamma rays. The data are discussed in terms of speculative models suggested by Hiraki and Saito. The annealing behaviors suggest the relation $C_{Sb} > C_{As} \geq C_P$ for the cross section C for interstitial germanium-impurity reactions. (auth)

**18029** LOW-TEMPERATURE THERMOLUMINESCENCE OF γ-IRRADIATED SINGLE CRYSTALS OF $CaCO_3$. Shul'ga, S. Z.; Bartnovskii, O. A.; Zver'kov, L. S. (Inst. of Physics, Kiev). Ukr. Fiz. Zh.; 14: 2042-7(Dec 1969). (In Russian).

Low-temperature (77 to 350°K) thermoluminescence was investigated in $CaCO_3$ single crystals γ-irradiated by a dose of $\sim 10^6$ R at 77°K. The thermoluminescence peaks were observed at 150, 190, and 230°K; the manganese impurity (about 1%) results in the disappearance of the peaks at 190 and 230°K and in the peak rise at 320°K. The presence of the 150°K peak may be explained by the recombination of the defective centers, including $CO_3^-$ ion of the triangular plane symmetry and a trapped electron localized in the vicinity of the $CO_3^-$ center; the 190°K peak presence is due to recombination of centers containing the $CO_3^-$ ion of the orthorhombic symmetry and trapped electron localized in the vicinity. It was established that the presence of the manganese impurity leads to the creation (formation) of at least two new types of defective centers. The defective center formation mechanism may be explained as ionization with subsequent electron trapping by neighboring traps; at the same time the γ irradiation of the $CaCO_3$ single crystals gives rise to an increase in the electron trap concentration. (auth)

**18030** CHANNELLING AND BLOCKING PHENOMENA IN THICK CRYSTALS AT CYCLOTRON ENERGIES. Acerbi, E.; Birattari, C.; Candoni, B.; Castiglioni, M.; Dutto, G.; Fait, G.; Succi, C. (Univ., Milan. Istituto Nazionale di Fisica Nucleare, Milan). Lett. Nuovo Cim.; 2: 805-9(11 Dec 1969).

Channeling and blocking effects were observed in thick crystals for a 31.5-MeV proton beam. 240-μm thick Si crystals were investigated for several different orientations; planar and axial channeling were detected. Similar star patterns were obtained for the ⟨100⟩ axis of a 500-μm thick W crystal. (D.L.C.)

**18031** ELECTRON PARAMAGNETIC RESONANCE OF ION-IMPLANTED DONORS IN SILICON. Brower, K. L.; Borders, J. A. (Sandia Labs., Albuquerque, N. Mex.). Appl. Phys. Lett.; 16: 169-73(15 Feb 1970).

The EPR of $^{75}As$, $^{121}Sb$, and $^{123}Sb$ substitutional donors implanted in silicon were observed. The Si–P3 and Si–P1 center resonances associated with the damage were also observed. Samples were implanted at room temperature to fluences of $\sim 10^{13}$ ions/$cm^2$, and the EPR spectra associated with the damage and the implanted impurities were monitored as the samples were isochronally annealed to 970°C. The spectra of the implanted donors were observed after the 400°C anneal with illumination and following the 600°C anneal without illumination. After the anneal at ~900°C, the proportion of implanted antimony that is observed by EPR to be substitutional is significantly larger than for the implanted arsenic. (auth)

## *Physical Properties*

*Refer also to abstracts 17298 and 18053.*

**18032** SURFACE PLASMA RESONANCES IN SMALL SPHERICAL SILVER AND GOLD PARTICLES. Kreibig, Uwe (Univ., Saarlands, Ger.); Zacharias, Peter. Z. Phys.; 231: 128-43 (1970).

With 51-keV electrons, surface plasma losses were investigated on small spherical Ag and Au particles embedded in a medium with dielectric constant $\epsilon_2 = 2.37$. The surface loss of particles with radii of about 50 Å is found at 2.99 ± 0.03 eV for silver and 2.34 ± 0.03 eV for gold, in good agreement with calculated values. For larger radii, the loss shifts to higher energy values which agrees qualitatively with the theory of Fujimoto and Komaki for the free electron gas. The optical extinction bands of the particles also have been measured. Their maxima are shifted to lower energies, in accordance with Mie's theory, if the particle size increases sufficiently. The energy values of the "electric" extinction bands and those of the surface plasmons correspond in theory and experiment, if the particles are small. Thus, the optical colloid extinction of Ag and Au may be interpreted as plasma resonance absorption and emission of the particles. (auth)

**18033** ELECTRON PHASE TRANSITION DISPLAY IN THE SUSCEPTIBILITY OF CADMIUM ALLOYS. Svechkarev, I. V.; Kuzimicheva, L. B. (Physical-Technical Inst. of Low Temperatures, Kharkov). Phys. Status Solidi; 37: K113-15(1 Feb 1970).

A model spectrum for the general orbital magnetism of electrons and the magnetic susceptibility with sharp drops of diamagnetism at the electron phase transitions are shown. A plot of the concentration dependences of susceptibility of Cd alloys with Hg up to 24 at. % and Mg up to 14 at. % at 4.2°K along the C-axis and normal to it. While $\chi_\perp$ changes little, $\chi_\parallel$ shows a complicated behavior, particularly for Mg; diamagnetism maxima at 0.5 and 6.5 at. % Mg alternate with minima at 1.7 and 10.2 at. %. The minima are identified with the electron phase transitions. (D.L.C.)

**18034** ELECTRON MICROSCOPIC INVESTIGATION OF THE DISLOCATION STRUCTURE IN MOLYBDENUM SINGLE CRYSTALS DEFORMED IN TENSION AT 293 AND 493°K. Luft, A.; Kaun, L. (Zentralinstitut fuer Festkoerperphysik und Werkstofforschung, Berlin. Institutsteil fuer Metallphysik und Reinstmetalle, Dresden). Phys. Status Solidi, 37: 781-93(1 Feb 1970).

The dislocation structure of high-purity molbydenum single crystals after weak tensile deformation at 293 and 493°K is studied by transmission electron microscopy. The transition from parabolic stress–strain behavior to three-stage hardening which occurs between the considered temperatures is associated with a basic change in the deformation substructure. Crystals deformed at 293°K contain a uniform distribution of long primary and secondary screw dislocations. On the contrary, the dislocation structure in stage I at 493°K consists mainly of isolated clusters of primary edge dipoles. It is concluded that the effect of temperature on the mobility of screw dislocations is responsible for the change observed both in work-hardening characteristics and related dislocation structures. (auth)

**18035** MOLECULAR SPECTROSCOPY WITH NEUTRONS. Boutin, Henri; Uip, Sidney Cambridge, Mass., Massachusetts Institute of Technology Press, 1968. 239p. $10.00.

The primary purpose of this work is to describe the use of neutron scattering in the study of molecular solids and liquids. The material is felt to be accessible not only to those already working with neutrons in molecular research, but also to optical spectroscopists and those in related fields who may be interested in results produced or in the techniques themselves. Sections are devoted to both theory and experimental studies. (L.M.T.)

**18036** SINGLE-CRYSTAL PREPARATION AND CRYSTALLINE ELECTRIC FIELD PARAMETERS OF $ErAl_2$. Purwins, Hans-Georg (Technische Hochschule, Munich). Z. Phys.; 233: 27-36(1970).

For the first time the preparation of single crystals of $ErAl_2$ and some isostructural compounds is described. From recently reported susceptibility measurements on $ErAl_2$ single crystals, the parameters of the crystalline electric field are calculated to be $B_4 = +15 \times 10^{-4}$K ± 30% and $B_6 = -2.1 \times 10^{-6}$K ± 30%. These parameters are discussed in terms of the point-charge model. This model describes $B_4$ and $B_6$ and the magnetic properties of $ErAl_2$ in good approximation. (auth)

**18037** LATTICE DYNAMICS OF ZnO AND BeO. Hewat, A. W. (Univ. of Melbourne). Solid State Commun.; 8: 187-9 (1 Feb 1970).

Phonon dispersion in ZnO has been mapped for frequencies up to $4 \times 10^{12}$ cps. A postulated low-frequency mode does not exist, and the results are in good agreement with the predictions of a simple shell model. Mean square vibrational amplitudes in ZnO and BeO are calculated. (auth) (UK)

**18038** DIFFUSION OF $^3$He AND $^4$He IN LiF. Kalbitzer, S.; Kiko, J.; Zaehringer, J. (Max-Planck-Institut fuer Kernphysik, Heidelberg). Z. Naturforsch.; 24a: 1996-2000(Dec 1969).

Helium isotopes were produced in single crystals of LiF by means of the nuclear reaction $^6$Li(n,$^3$H)$^4$He and by the subsequent decay of $^3$H into $^3$He. At a constant temperature of 620°C, the isotopic ratios of the outgassed helium isotopes were measured as a function of time respectively as a function of the released fraction. The ratio of the diffusion constants $D_3/D_4$ was found to be at most 1.02 which is considerably smaller than the maximum classical value of 1.155. (auth)

**18039** COERCIVITY OF $SmCo_5$. Westendorp, F. F. (Philips Research Labs., Eindhoven, Netherlands). Solid State Commun.; 8: 139-41(1 Feb 1970).

The influence of certain heat treatments on the coercivity of $SmCo_5$ is investigated. It is found that the coercivity decreases after heating above 800°C but increases at higher temperatures. A model accounting for the high coercivity is proposed which is based on pinning rather than on nucleation of domain walls. (auth) (UK)

**18040** METALLIC HYDROGEN. Schneider, T. Helv. Phys. Acta; 42: 957-89(30 Dec 1969).

Metallic hydrogen is considered as an array of protons embedded in a sea of electrons. This system is described in terms of the adiabatic approximation. The electronic contribution to the potential energy of the lattice is calculated by use of a modified Hartree–Fock method. Starting from free electrons, the electron–proton interaction is introduced as a perturbation in a self-consistent manner. On this basis the following properties are discussed: lattice energy, lattice dynamics, lattice stability, effective proton–proton interaction, electron band structure, and superconductivity. In addition, the phase transition between molecular and metallic modifications is discussed. Results enable quantitative statements about the relation between electronic structure, crystal stability and phonon zero-point energy to be made. They suggest that increasing pressure leads to a phase transition from the metallic solid state into the liquid state due to the phonon zero-point energy. The results, furthermore, imply interesting astrophysical consequences and indicate that metallic hydrogen may be a high-temperature superconductor. (auth)

### *Moessbauer Effects and NMR*

*Refer also to abstracts 16431, 16931, and 16932.*

**18041** INTRODUCTION OF MAGNETIC EQUIVALENCE IN ANALYSIS OF HIGH-RESOLUTION NMR SPECTRA BY THE LEAST-SQUARES METHOD. Musso, Jean A.; Isaia, Annick (Faculte des Sciences, Nice). J. Chim. Phys.; 66: 1676-81 (Oct 1969). (In French).

An extension of the LAOCN-3 program written by Bothner-By and Castellano (J. Chem. Phys., 41: 3863-9(1964)) for the analysis of high-resolution nuclear magnetic resonance spectra by a least-squares method is described. The Hamiltonian matrix is factored to reduce it to minimal dimension by taking advantage of magnetic equivalence. The algorithm used for this factorization is described by Ferfuson and Marquardt (J. Chem. Phys., 41: 2087-95 (1964)). The new program, called NMR-LAOCN-4A is written in the FORTRAN IV language for the IBM 1130-2B or 3B computer. (auth)

**18042** THE BLOCH–SIEGERT EFFECT IN THE DYNAMIC POLARIZATION OF NUCLEI. Alekseev, B. F. (Leningrad Electrotechnical Inst.). Izv. Vyssh. Ucheb. Zaved., Radiofiz.; 12: 1430-2(1969). (In Russian).

The frequency shift of nuclear magnetic resonance upon the application of a circularly polarized magnetic field—the so-called Bloch–Siegert effect—is most marked for weak magnetic fields. This phenomenon was examined in the case of the dynamic polarization of nuclei. The field required to saturate the electron paramagnetic resonance for aqueous $Mn^{2+}$ solutions was found to exceed 10 Oe; the derived expressions were used to recalculate the frequency shift, obtaining a static gyromagnetic relation. Equations were derived to determine the necessary stability of the generator used for saturating the epr, taking into account the overall error of the measuring instruments. (TTT)

**18043** HYPERFINE INTERACTIONS AND ANISOTROPIC LATTICE VIBRATIONS OF $^{237}$Np IN $\alpha$–Np METAL. Dunlap, B. D.; Brodsky, M. B.; Shenov, G. K.; Kalvius, G. M. (Argonne National Lab., Ill.). Phys. Rev., B; 1: 44-9(1 Jan 1970).

Hyperfine spectra utilizing the nuclear $\gamma$-ray resonance (Moessbauer effect) of the 59.6-keV $\gamma$ ray of $^{237}$Np have been obtained in $\alpha$-Np metal. For the temperature range 1.7–48°K, the spectra show no magnetic effects and can be described as two quadrupole interactions having widely differing values of electric field gradient and asymmetry parameter. These two spectra can be related to the two inequivalent sites in the orthorhombic unit cell of $\alpha$-Np. The intensities of the hyperfine lines show the presence of anisotropic lattice vibrations (Goldanskii–Karyagin effect). At one site the lattice vibrations are only slightly anisotropic, while for the other site a maximum rms deviation of ≈0.1 Å is deduced. (auth)

**18044** THEORY OF OVERHAUSER NUCLEAR EFFECT IN MULTISPIN SYSTEMS. Tumanov, V. S. Vestn. Mosk. Univ., Ser. III, Fiz. Astron.; No. 5, 106-12(Sep-Oct 1969). (In Russian).

The theory of partial and integral Overhauser nuclear effect in $A_iX_k$ type systems was studied. Equations were obtained for the longitudinal components of magnetizations in the $A_iR_k$ systems. A generalized formula was developed for the partial effect under independent relaxation conditions. Calculations took into account the intramolecular dipole relaxation and relaxation produced by fluctuating fields. The calculations were based on the derived indenticality binding probabilities of relaxation processes. (tr-auth)

## Theoretical Physics

**18045** (ORNL–4431) ANALYSIS OF GROUND-STATE ENERGY EIGENFUNCTIONS FOR FINITE DIPOLE IN SPHERICAL COORDINATE SYSTEMS. Garrett, W. R.; Turner, J. E.; Anderson, V. E. (Oak Ridge National Lab., Tenn.). Feb 1970. Contract W-7405-eng-26. 51p. Dep. CFSTI.

Ground-state-energy eigenfunctions for an electron in the field of a stationary, finite electric dipole are expressed in spherical polar coordinates with the origin taken at (1) the location of the positive dipole charge and (2) the center of the dipole. The mixtures of radial and angular functions are calculated for dipole moments (D, in atomic units, $ea_0$) through the range $0.64 \leq D \leq 100$. The functions so expressed can be used in perturbation calculations of the effects of other potentials on the interaction of electrons with polar molecules. They also show the number and relative importance of various partial waves pertinent to low-energy scattering of electrons by polar molecules. The direct numerical solution for the ground state of the electron in the field of a stationary finite dipole is given in spherical polar coordinates. (auth)

**18046** LONGITUDINAL ELECTRICAL CONDUCTIVITY OF A RELATIVISTIC GAS IN AN INTENSE MAGNETIC FIELD. Canuto, V.; Chiu, H.-Y. (Goddard Space Flight Center, New York). Phys. Rev.; 188: 2446-54(25 Dec 1969).

The electrical conductivity for an electron gas is computed when a strong quantizing magnetic field is present. This strong field ($\approx 10^{13}$ G) is thought to exist in the interior of a neutron star. The knowledge of the conductivity is of primary importance for the evaluation of the decay time of the magnetic field due to Ohmic dissipation. This is a critical quantity in most of the recent developments of pulsars as magnetized neutron stars. The chief scattering process is Coulomb scattering by ions. For a magnetic field of the order of $10^{13}$ G, the conductivity is higher by a factor 10 to $10^2$

with respect to the case without a magnetic field The ion–ion correlation is included through the use of the static pair-correlation function. Its effect is that of increasing the conductivity by a factor of 2. (auth)

**18047** POINT SOURCE OF PARTICLES WITH EXPONENTIAL DECREASE IN THE SCHROEDINGER THEORY. Gillot, Genevieve (Institut de Calcul Numerique, Toulouse). Compt. Rend., Ser. B; 269: 793-6(29 Oct 1969). (In French).

Previously, the output of particle sources, which is not an initially known quantity, was joined to a second member of the Schroedinger equation; the output of a point source that begins to operate at the time $t = t_0$ and tends toward a constant value was studied. The production of the $\Psi$ wave by the source is studied, here, and this study is extended to the case of a source of which the output has an exponential decrease when $t \gg t_0$. This case is interesting because it corresponds to particle sources made with radioactive nuclei. (tr-auth)

**18048** ELECTRON MOVEMENT IN ELECTROMAGNETIC WAVE IN THE PRESENCE OF A PARALLEL FIELD. Berson, I. Ya. (Inst. of Physics, Riga). Latv. PSR Zinat. Akad. Vestis, Fiz. Teh. Zinat. Ser.; No. 5, 3-8(1969). (In Russian).

The problem of electron interaction with the quantized field of a plane monochromatic electromagnetic wave in the presence of a permanent magnetic field directed parallelly to the wave propagation is solved. The solution of the problem considered is analogous to that elaborated by the author previously (Zh. Eksp. Teoret. Fiz., 56: 1627(1969)) for a variant without the parallel magnetic field. Changes in the wave function at transition from the quantized field of the monochromatic electromagnetic wave to the classical, unquantized, wave are also considered. (auth)

**18049** PECULIARITIES OF TRANSIENT RADIATION AND VAVILOV–CHERENKOV RADIATION IN FERRITES. Ryazantsev, K. A. (Novosibirsk State Teachers Inst., USSR). Izv. Vyssh. Ucheb. Zaved., Radiofiz.; 13: 28-32(1970). (In Russian).

The radiation from a charged particle moving along the interface of vacuum and ferrite, having two magnetic subarrays, is considered. The radiation is shown to be elliptically polarized. The spectral density of radiation is found and the possibility of emerging Cherenkov radiation into vacuum when the particle is moving from vacuum into the medium is investigated. (auth)

**18050** QUANTUM MECHANICS. SECOND EDITION. Merzbacher, Eugen. New York; John Wiley and Sons, Inc. (1970). 630p. $13.95.

An outstanding feature in this new edition is the stress placed on second quantization as a natural development of ordinary one-particle quantum mechanics. New chapters deal with typical many-body problems and with photons and relativistic electrons. The free radiation field and the free Dirac electron–positron field are treated in detail, and the theory of each field in the presence of classical sources is developed. The book stops short of the theory of interacting quantum fields, with the last chapter discussing the one-particle Dirac theory of the electron. (TSS)

**18051** CHERENKOV RADIATION IN A DIELECTRIC LAYER. Santavy, I. (Technical Univ., Brno). Czech. J. Phys.; 20: 115-25(1970).

An investigation was made of the Cherenkov radiation field generated in an infinite plane-parallel layer by a sinusoidally bunched beam of electric charges moving with constant velocity along its surface. (auth)

**18052** ON FLUCTUATION–DISSIPATION THEOREMS AND THEIR APPLICATIONS AND ON BURGERS' TURBULENCE MODELS. Chiu, Shiu-chu. Ann Arbor, Mich.; Univ. of Michigan (1969). 97p.

Thesis.

This work is composed of two separate parts. In the first part, the fluctuation–dissipation theorems connecting the correlations of macroscopic quantities and the linear phenomenological coefficients are derived for the relaxation functions and the response functions using perturbation theory. They are applied to the following four systems: (i) Stationary correlations of macroscopic quantities such as density, entropy etc., are calculated for the Navier–Stokes equations; they are delta functions in space and are independent of viscosity and thermal conductivity. (ii) The same calculations are carried out for the Krook Model. The correlations agree with those for an ideal gas. (iii) Both the stationary and the spectral correlations of charge densities etc., are calculated for the Vlasov plasma. The stationary correlations reveal the Debye shielding effect. The spectral correlations are singular at the eigenfrequencies of the plasma oscillations. (iv) The spectral correlations of electromagnetic fields and the energy spectrum are calculated for a cavity with an absorptive medium. The energy spectrum consists of Lorenztian spikes whose peaks are near the eigenfrequencies of the cavity and are enveloped by the Planck's distribution. The spectrum approaches the Planck's law asymptotically. In the second part, the stabilities and transitions of the solutions of the Burgers' Models of turbulence are considered near the critical points. The process of the onset of turbulence as described by Landau and deviations from his description are demonstrated using the Bolgolyubov–Mitropolskii perturbation method. It is found that continuous transitions exactly analogous to those described by Landau occur at some critical points, but in other critical points, infinitesimal changes of the parameter cause finite changes in the solutions. (Diss. Abstr.)

**18053** SCREENED HYDROGEN-LIKE IMPURITY IN A STRONG MAGNETIC FIELD. Ortenberg, M. V.; Landwehr, G. (Univ., Wuerzburg, Ger.). Phys. Status Solidi; 37: K69-73 (1 Feb 1970).

The energy levels of a screened hydrogen atom in semiconductors are calculated for strong magnetic fields. An effective Hamiltonian and eigenvalues are derived for motion in the z direction. Reduced binding energies $E_{Bind}/E_H$ are plotted versus the magnetic field parameter $\gamma$. (D.L.C.)

**18054** POLARON MODEL OF THE SOLVATED ELECTRON: THE ELECTRONIC AND ORIENTATIONAL POLARIZATION. Moorthy, P. N.; Shankar, J. (Bhabha Atomic Research Centre, Bombay). Radiat. Eff.; 2: 91-5(Jan 1970).

The classical "Polaron" model of the solvated electron is reconsidered, taking into account only the electronic polarization. This approach provides good agreement between calculated and experimental optical absorption maxima of this species in a number of systems and predicts a red shift in the optical absorption maximum with increasing temperature in the case of both water and ice in agreement with the experimental finding. Trapping potential for the electron obtained on the basis of electronic polarization only turns out to be about the same as that obtained on the basis of the classical approach. It is also shown that in order to confine the electron within one molecular distance from the origin during the time taken for dipolar orientation, the corresponding relaxation time must be of the order of $10^{-15}$–$10^{-16}$ sec, i.e., corresponding to optical frequencies. (auth)

**18055** POLARIZATION OF ELECTRONS IN MAGNETIC FIELDS BY ELECTROMAGNETIC WAVES. Gal'tsov, D. V. Vestn. Mosk. Univ., Ser. III, Fiz. Astron.; No. 5, 57-64(Sep-Oct 1969). (In Russian).

The possibility of polarization of electrons in a magnetic field by external electromagnetic radiation is investigated. Estimates are made of the coefficient and effective time of polarization as functions of the wave field intensity. (tr-auth)

# PHYSICS (HIGH ENERGY)

## Particle Interactions and Properties (Experimental)

18056 (BNL-50169) ANNUAL REPORT, JULY 1, 1969. (Brookhaven National Lab., Upton, N. Y.). 243p. Dep. CFSTI.

The progress and trends of the research programs in particle physics, nuclear structure, neutron physics, solid state physics, theoretical physics, high energy accelerators, instrumentation, chemistry, applied science and mathematics, biology, and medical research are summarized. The operational, service, and administrative activities are also briefly outlined. A list of all publications published or submitted during the year is appended. (C.E.S.)

18057 SEARCH FOR FRACTIONALLY CHARGED PARTICLES. Cook, D. D.; DePasquali, G.; Frauenfelder, H.; Peacock, R. N.; Steinrisser, F.; Wattenberg, A. (Univ. of Illinois, Urbana). Phys. Rev.; 188: 2092-7(25 Dec 1969).

A geophysical search for fractionally charged particles in seawater and rock samples was performed. The samples were run through cation exchange columns to separate most of the material from particles of charge $\pm\frac{2}{3}$ and $\pm\frac{1}{3}$. The purified samples were converted into azides and evaporated in an electron gun, which accelerated the negatively charged particles to a solid-state detector. Quarks with charge $+\frac{2}{3}$ ($q_1$) would probably evaporate from azides as ($q_1$ + e) and would thus have an effective charge of $-\frac{1}{3}$. The pulse-height spectra from the detector were scanned for peaks corresponding to particles of a charge between −1 and 0; no such particles were found. Limits on the concentration of $q_1$ quarks are $\lesssim 10^{-23}$ quarks/nucleon in the rock samples and $\lesssim 10^{-24}$ quarks/nucleon in the seawater samples. These limits depend, of course, on the assumptions concerning the chemical behavior of quarks made in the text. (auth)

18058 ELEMENTARNYE CHASTITSY I KOSMICHESKIE LUCHI. SBORNIK STATEI. VYPUSK 2. (Elementary Particles and Cosmic Rays. Collection of Articles. Issue 2). Gal'per, A. M.; Ponosov, A. K. (eds.). Moscow; Atomizdat (1969). 192p.

Twelve articles on cosmic radiation and elementary particle physics are included. Problems related to muons, electrons, photons, a search for quarks and fireballs in cosmic rays and particle interactions in accelerators are discussed. Measurements of electron and $\gamma$ quantum fluxes with over 100-MeV energies at various atmospheric elevations, studies of fireballs, cosmic muons and cascade showers are covered. Experiments on seeking out heavy particles at sea level, resonances in $K\bar{K}$ and $K\Lambda$ systems, generation of pseudoscalar meson octets in nuclear Coulomb field and meson on meson photoproduction are discussed. Determination of the nn-scattering length in experiments on $\mu$-meson capture $\pi^+$ meson absorption by complex nuclei, measurements of electron tracks, electron and $\gamma$-quanta energies in heavy-liquid bubble chamber, and the mechanism of gas scintillation are discussed. (R.V.J.)

### Electromagnetic

*Refer also to abstract 18340.*

18059 (CERN-69-29, pp 61-95) PHYSICS WITH ELECTRON–POSITRON COLLIDING BEAMS. Haissinski, J. (Paris Univ., Orsay (France). Laboratoire de l'Accelerateur Lineaire).

A description of some specific features of $e^+$–$e^-$ colliding beam rings and of the experiments performed using these rings is given. Also a rapid survey of recent results is presented. The main characteristics of electron–positron colliding beam rings, detection, purely electromagnetic channels, strong interactions, and asymptotic behavior are covered. (J.F.P.)

18060 (CONF-690330) MORIOND CONFERENCE ON ELECTROMAGNETIC INTERACTIONS, 11–21 MARCH 1969, ORSAY FRANCE. (Paris Univ., Orsay (France). Laboratoire de l'Accelerateur Lineaire. Paris Univ., Orsay (France). Laboratoire de Physique Theorique et Hautes Energies). 250p. (In French and English).

The conference included 20 papers. Separate abstracts were prepared for each paper. (J.F.P.)

*For abstracts of individual papers see: 16883, 18061–18063, 18072, 18074, 18108–18111, 18150, 18151, 18160, 18185–18188, 18245, 18256, and 18317.*

18061 (CONF-690330-, pp 2-14) STUDY OF THE PRODUCTION OF $\omega$ AND $\phi$ WITH THE ORSAY COLLISION RINGS. Richard, F. (Paris Univ., Orsay (France). Laboratoire de l'Accelerateur Lineaire). (In French).

The Orsay collision rings were used to study electron–positron interactions with production of mesons ($\omega$) and ($\phi$). Curves are given showing the excitation of these resonances. (J.F.P.)

18062 (CONF-690330-, pp 15-34) MEASUREMENT OF THE WIDTH OF THE MESON RHO ZERO WITH THE ORSAY COLLISION RINGS. Rumpf, F. (Paris Univ., Orsay (France). Laboratoire de l'Accelerateur Lineaire). (In French).

Measurements are made of the cross section of the reaction $e^+ + e^- \rightarrow \rho^0 \rightarrow \pi^+ + \pi^-$. These measurements are made for energy distributions of the meson ($\rho^0$) using spark chambers. Values for the resonance are found for a half-width, width, and the width at half maximum. (J.F.P.)

18063 (CONF-690330-, pp 73-80) PHYSICS WITH AN ELECTRON–POSITRON COLLISION RING OF SEVERAL GeV. Perez-Y-Jorba, J. (Paris Univ., Orsay (France). Laboratoire de l'Accelerateur Lineaire). (In French).

The various interactions which can be studied using electron–positron collision rings are briefly described. These interactions include quantum electrodynamics interactions, baryon–antibaryon interactions, production of mesons, $W + \overline{W}$ interactions, the $e\mu\gamma$ vertex, and charge conjugation violation. Also the experimental arrangement and the effects of radiative corrections are discussed. (J.F.P.)

18064 COSMIC RAY ELECTRON SPECTRUM ABOVE 200 GeV. Anand, K. C.; Daniel, R. R.; Stephens, S. A. (Tata Inst. of Fundamental Research, Bombay). Nature (London); 224: 1290-1(27 Dec 1969).

It is stated that the shape of the spectrum of cosmic ray electrons in the GeV range and beyond can provide information about a variety of problems in cosmic ray astrophysics. For the studies beyond 200 GeV a pure nuclear emulsion stack was flown horizontally in a balloon launched from Hyderabad, India. Evidence was obtained for nearly 100% detection efficiency at >200 GeV. Tracks were counted in a circle of radius 68$\mu$m in all emulsions within the lead-emulsion assembly. These measurements determined the longitudinal development of the cascade, and thus the energy of the incident electron could be estimated. So far 35 electrons >100 GeV were found at the top of the atmosphere, of which 22 are 200 GeV. The highest energy observed so far is 670 GeV. Of the 22 electrons >200 GeV, 20 had associated electron pairs and/or tridents in the pure emulsion stack, confirming their electronic nature. A power-low-spectrum equation is derived to fit the results. It is stated that there is good evidence to believe that a steepening of the spectrum occurs >200 GeV. Several important consequences of steepening of the spectrum by one power at ≈200 GeV are discussed. (UK)

18065 MEASUREMENT OF THE RATIO OF THE PROTON FORM FACTORS, $G_E/G_M$, AT HIGH MOMENTUM TRANSFERS AND THE QUESTION OF SCALING. Litt, J. (Stanford Univ., Calif.); Buschhorn, G.; Coward, D. H.; (and others). Phys. Lett.; 31B: 40-4(5 Jan. 1970).

Electron-proton elastic scattering cross sections were measured at the Stanford Linear Accelerator Center at four-momentum transfers squared ($q^2$) of 1.0, 1.5, 2.0, 2.5, and 3.75 $(GeV/c)^2$. The angular distributions at $q^2 = 2.5$ and 3.75 $(GeV/c)^2$ are sufficient to provide values of the ratio $G_E/G_M$ independent of the results from other laboratories. The results are compatible with scaling, $G_E(q^2) = G_M(q^2)/\mu$, within the experimental errors. (auth)

18066 PHOTOPRODUCTION OF $\pi$-MESONS FROM NUCLEI. Kitagaki, Toshio; Homma, Saburo (Tohoku Univ., Sendai). Res. Rep. Lab. Nucl. Sci., Tohoku Univ.; 2: No. 1, 52-6(Jun 1969). (In Japanese).

The measurement of $\pi$-mesons photoproduction from nuclei was made. Natural calcium and carbon were used as target nuclei. An electron beam of energy 250 MeV and mean current 30 $\mu$A was converted on an Al foil of 20 $\mu$ in thickness into bremsstrahlung. Targets were 0.75 g/cm$^2$ Ca and 1.00 g/cm$^2$ C. Mesons ($\pi^\pm$) produced in the interaction of $\gamma$-ray with intranuclear nucleons, $\gamma + p \rightarrow n + \pi^+$ and $\gamma + n \rightarrow p + \pi^-$, were detected with a magnetic spectrometer set up at right angles in the laboratory system. The result after proper correction was shown. The sum of $\pi^+$ and $\pi^-$ yields vs atomic number A was plotted and compared with the prediction of relative yields from the optical model normalized at Al. The ratio of negative to positive meson yields in C, Al, Ca

as the function of meson energy was also plotted. Some factors affecting this ratio were enumerated. (auth)

18067 PHOTOPRODUCTION OF NEUTRAL PIONS IN HELIUM BY 335-MeV BREMSSTRAHLUNG. Staples, John William. Urbana, Ill.; Univ. of Illinois (1969). 147p.

Thesis.

The differential cross section was measured for the coherent production of neutral pions from $^4$He by photons to an energy of 335 MeV. Bremsstrahlung from the University of Illinois 340 MeV betatron impinged upon a gaseous $^4$He target cooled to 20.4°K. The recoil nucleus was detected with a semiconductor telescope in coincidence with at least one gamma resulting from the decay of the neutral pion. The particle events were recorded on photographic film in both analogue and digital form. The resolution of the recoil telescope was sufficient to permit separation of the $^4$He recoils from the background of $^3$He recoils and allowed a better identification of the coherent $^4$He events that had been achieved earlier. The laboratory cross sections were found to vary from 40 $\mu$b/Sr at 20° and 230 MeV photon energy decreasing with energy to 55 $\mu$b/Sr for the single measurement at 50° for a photon energy of 320 MeV. These cross sections are moderately smaller than those given by Palit and Bellamy and are much smaller than earlier measurements by DeSaussure and Osborne. The experimental cross sections are compared with those calculated by means of an impulse approximation, using the amplitudes for the photoproduction of neutral pions from nucleons. The laboratory energy and angle of the $^4$He recoil define the kinematic variables in the $^4$He system but do not explicitly define the variables in the nucleon system, which are required to evaluate the nucleon photoproduction amplitude. The correct evaluation of these variables is a difficult problem involving appropriate averages of the effects of nucleon motion within the nucleus. Three simplified ways of specifying the variables in the nucleon frame are presented and compared to each other with respect to their usefulness of representing the experimental results. Calculations done elsewhere show that corrections to the impulse approximation for interactions of the pion in the final state reduce the predicted cross section by about a factor of two in the resonance region. Using this correction and specifying the center-of-mass pion momentum and gamma energy variables equal in the nucleon and helium frames gives reasonable agreement with the experimental cross sections. (Diss. Abstr.)

18068 MULTIPION AND STRANGE-PARTICLE PHOTOPRODUCTION ON PROTONS AT ENERGIES UP TO 5.8 GeV. Erbe, R. (Technische Hochschule, Aachen); Hilpert, H. G.; Schuettler, E.; (and others). Phys. Rev.; 188: 2060-77(25 Dec 1969).

In a study of photoproduction at photon energies between 0.3 and 5.8 GeV in a hydrogen bubble chamber, approximately 1.7 million pictures containing about 31,000 events with three or more outgoing charged particles were analyzed. This is the second of two final reports on this experiment. Distributions of effective masses are given for the reactions $\gamma p \to N3\pi$, $N4\pi$, $N5\pi$. Cross sections for the production of $\Delta(1236)$ and $\rho$ via $\gamma p \to \Delta\rho$, $\Delta 2\pi$, $\Delta 3\pi$, $\Delta 4\pi$, $N\pi\rho$, and $N2\pi\rho$ and of various other reactions are reported. From the reaction $\gamma p \to \Delta^{++}\rho^-$, an upper limit for the radiative decay width of $\rho^-$, $\Gamma(\rho^- \to \pi^-\gamma) < 0.24$ MeV, is obtained (90% confidence). For the four-pion decay mode of the $\rho^0$, an upper limit of $\Gamma(\rho^0 \to \pi^+\pi^+\pi^-\pi^-)/\Gamma(\rho^0 \to \pi^+\pi^-) < 0.0015$ is found (90% confidence). The photoproduction of strange particles is discussed and cross sections for $\gamma p \to \Lambda K^+$, $\Sigma K$, $\Lambda K\pi$, $\Sigma K\pi$, and $\Lambda K\pi\pi$ are presented. Production of $\Sigma(1385)$ was observed. (auth)

18069 PHOTOPRODUCTION OF CHARGED MESONS FROM ATOMIC NUCLEI. Kitagaki, Toshio; Honma, Saburo (Tohoku Univ., Sendai). Res. Rep. Lab. Nucl. Sci., Tohoku Univ.; 1: No. 2, 49-55(Dec 1968). (In Japanese).

The photoproduction of charged pions from atomic nucleus is the effective means for studying the interaction of pions with nuclear matter. The electron linac in this laboratory was used for this purpose. An electron beam was converted at the Al-foil radiator into bremsstrahlung, which was led through a Cu collimator to the target. C, Cu and Al were used as the target. Charge and momentum of the produced pion were measured with a magnetic spectrometer. The counter system was composed of three scintillation counters and a Čerenkov counter. Pion identification was realized with a $d_E/d_X$ counter and a Čerenkov counter. The measured energy spectrum of produced $\pi^+$ and $\pi^-$ was shown. A-dependence of the $\pi^-$-yield was compared with the calculation based on optical model. $\pi^-/\pi^+$ ratio in this experiment was compared with the previous data by Littauer-Walker. Agreement within the error of measurement was obtained. (auth)

18070 STATUS AND PERSPECTIVES OF PHOTOPRODUCTION EXPERIMENTS. Heusch, Clemens A. (California Inst. of Tech., Pasadena). Contract AT(11-1)-68. pp 469-581 of Theory and Phenomenology in Particle Physics. Part B. /Zichichi, A. (ed.). New York; Academic Press Inc. (1969).

Recent developments in the field of photon-initiated hadron interactions giving a nucleon and boson final state are reviewed. The photoproduction of single nonstrange pseudoscalar and vector meson data, problems and interpretation is stressed. (J.F.P.)

18071 PHOTOPRODUCTION OF CHARGED MESONS FROM ATOMIC NUCLEUS. Kitagaki, Toshio; Honma, Saburo (Tohoku Univ., Sendai). Res. Rep. Lab. Nucl. Sci., Tohoku Univ.; 1: No. 1, 33-6(1968). (In Japanese).

The study of meson physics near threshold was planned, and as the first step a test experiment was performed on the detection of $\pi$-mesons produced by $\gamma$-rays. A $\gamma$-ray with the intensity of about $2 \times 10^9$ equivalent quanta was obtained from an Al (10 $\mu$m) bremsstrahlung target by 260 MeV electron beam. The $\gamma$-ray was led through a Pb collimator of 5 mm $\phi$ to the C-target 4 mm thick. Charged particles from the target nuclei were deflected by $\alpha$ magnet to discriminate the charge and the momentum of the particles. The counting rate of $\pi$-mesons was about 1 pion/sec at the peak of momentum distribution ($T_\pi$ = 60 MeV). Background was about ±10%. A range telescope was composed of four scintillation counters with Cu- or Pb-absorbers inserted. Production of $\pi^+$ and $\pi^-$ was ascertained. The momentum distribution of the produced $\pi^+$ and $\pi^-$ could be measured. This experiment was performed with the electron linac at the Tohoku University. (auth)

## Weak

18072 (CONF-690330-, pp 90-5) ADLER'S TEST OF THE PCAC HYPOTHESIS. Masnou, J. L. (Paris Univ., Orsay (France). Laboratoire de l'Accelerateur Lineaire). (In French).

Neutrino events obtained previously in a heavy-liquid bubble chamber and meson ($\pi^+$) interactions at 0.216 to 1.934 GeV/c in a propane bubble chamber are considered. It is concluded that the Adler test can verify the PCAC hypothesis for angles less than 8° particularly for $q^2$ below 0.1 (GeV/c)$^2$. (J.F.P.)

18073 EXPERIMENTAL STUDY OF THE DECAY $K_L \to \pi^0\pi^0$ AND OTHER RARE DECAY MODES. Banner, M.; Cronin, J. W.; Liu, J. K.; Pilcher, J. E. (Princeton Univ., N. J.). Phys. Rev.; 188: 2033-59(25 Dec 1969).

The branching ratio $\Gamma(K_L \to 2\pi^0)/\Gamma(K_L \to 3\pi^0)$ was measured to be $(4.6 \pm 1.1) \times 10^{-3}$. This leads to $\Gamma(K_L \to 2\pi^0)/\Gamma(K_L \to \text{all}) = (0.97 \pm 0.23) \times 10^{-3}$ and a CP-violation parameter $|\eta_{00}| = (2.2 \pm 0.3) \times 10^{-3}$. Other branching ratios measured were $\Gamma(K_L \to \gamma\gamma)/\Gamma(K_L \to \text{all}) = (4.7 \pm 0.6) \times 10^{-4}$, $\Gamma(K_S \to \gamma\gamma)\ \Gamma(K_S \to \text{all})$ <0.2 with 90% confidence and $\Gamma(K_L \to \pi^0\gamma\gamma)/\Gamma(K_L \to \text{all}) < 2.3 \times 10^{-4}$ with 90% confidence. (auth)

## Strong (Baryon-Induced)

*Refer also to abstracts 16883, 18096, 18097, 18101, 18104, 18105, and 18314.*

18074 (CONF-690330-, pp 112-29) EXPERIMENTATION WITH THE CERN INTERSECTING STORAGE RINGS. Bellettini, G. (Pisa Univ. (Italy). Istituto di Fisica).

A summary is given of the main characteristics of CERN intersecting storage rings. The future experimental program is discussed and includes a study of the total and elastic differential p + p cross sections, the differential cross section for isobar production in quasi-two-body interactions such as p + p → p + N*, and stable particle production at various angles. (J.F.P.)

18075 ELASTIC INTERACTIONS OF ANTIPROTONS WITH DEUTERONS BETWEEN 1.23 AND 1.67 GeV/c. Berrhyill, John Ralph. Madison, Wis.; Univ. of Wisconsin (1969). 126p.

Thesis.

The results of a study of those interactions of antiprotons with deuterons which are elastic in the sense that the products are only an antiproton and a deuteron, or its constituent nucleons are reported. These reactions include $\bar{p}d \to \bar{p}p(n)$ and $\bar{p}d \to \bar{p}n(p)$ [impulse approximation antiproton-nucleon scattering, (N) denoting a spectator nucleon], $\bar{p}d \to \bar{p}d$ [elastic scattering from the intact deuteron], and $\bar{p}d \to \bar{p}np$ [breaking up of the deuteron outside the realm of the impulse approximation.] The data are derived from the analysis of 97,000 photographs made with a deuterium bubble chamber exposed to a beam of antiprotons with momentum between 1.23 and 1.67 BeV/c. Details of the experimental method are given with particular emphasis on the means employed to treat $\bar{p}d \to \bar{p}n(p)$ when the proton is unobserved and on the techniques used to identify $\bar{p}d \to \bar{p}d$. The first measurements of $\bar{p}d$ and impulse-approximation $\bar{p}n$ differential scattering cross sections are reported for a wide range of momentum transfers. The $\bar{p}n$ distri-

bution is compared to $\bar{p}p$ and is found to exhibit a more significant energy dependence, which, however, is interpreted not to constitute sufficient evidence for the presence of boson resonances coupled to the $\bar{N}N$ direct channel. The $\bar{p}d$ angular distribution is found to be in agreement with the theoretical predictions of Franco, Glauber, and Harrington. The consistency of $\bar{p}d$ theory and experiment is shown to imply support for the validity of the shielding corrections commonly used in the interpretation of $\bar{p}d$ total cross section data. Within the framework of the theory, it is found that if the small-angle $\bar{p}n$ elastic amplitude is parameterized by $f_n = (i + \alpha_n)(k\sigma_n/4\pi) \exp(A_n t/2)$, then $A_n = (20 \pm 2)$ (BeV/c)$^{-2}$, $|\alpha_n| = 0.3 \pm 0.3$, and $\alpha_n$ has the same sign as $\alpha_p$. (Diss. Abstr.)

18076 $\bar{p}$–p ANNIHILATIONS TO K AND $\pi$ MESONS AT 2.7 GeV/c. Schroeder, L. S. (Ames Lab., Iowa); Kernan, W. J.; Fisher, G. P.; Eide, A. J.; von Krogh, J.; Libby, L. Marshall; Sears, R. Phys. Rev.; 188: 2081–8(25 Dec 1969).

Results are reported on the reactions $\bar{p} + p \rightarrow K + \bar{K} + n\pi$ (n = 1, 2, . . .) at 2.7 GeV/c. The cross section for this process is estimated to be 4.1 ± 0.6 mb. Comparison of 2.7-GeV/c partial cross sections with data at 3.0 and 3.7 GeV/c indicates that these partial cross sections either are relatively constant or slowly decrease with energy. $K^*(890)$ production is observed in all the four-, five-, and six-body final states. The production of $\rho^0$ and $\omega^0$ is also observed. The $K\bar{K}$ mass spectra show enhancements near threshold as has been seen in other $\bar{p}$–p experiments. The present data cannot distinguish between a resonance or S-wave scattering-length interpretation of these enhancements. No significant evidence for resonances decaying into $K\pi\pi$ or $K\bar{K}\pi$ was observed. (auth)

## *Strong (Meson-Induced)*

18077 (UCRL-18139) STUDY OF $\pi^- + p \rightarrow \Lambda + K^0$ FROM 944 MeV/c TO 1170 MeV/c. Doyle, Joseph Cecil (California Univ., Berkeley. Lawrence Radiation Lab.). Dec 1969. Contract W-7405-eng-48. Dep. CFSTI.

Thesis.

The process $\pi^- + p \rightarrow \Lambda + K^0$ was studied at incident beam momenta of 944, 966, 986, 991, 1006, and 1170 MeV/c in the Lawrence Radiation Laboratory 72-inch hydrogen bubble chamber. Differential and total cross sections and polarizations are presented. An attempted partial-wave analysis incorporating previously reported data at 1030 MeV/c is described and two solutions found are compared with other results. (auth)

18078 (UCRL-19431) $\eta'$ PRODUCTION IN $\pi^+$d INTERACTIONS FROM THRESHOLD TO 2.4 GeV/c. Rader, Robert K. (California Univ., Berkeley. Lawrence Radiation Lab.). Dec 1969. Contract W-7405-eng-48. 71p. Dep. CFSTI.

Meson ($\eta'$) production is studied as part of an experiment using a $\pi^+$ beam incident on deuterium in the 72-in. bubble chamber, with beam momenta from 1.1 to 2.4 GeV/c. The $\eta'$ is produced in the reaction $\pi^+d \rightarrow pp\eta'$, and the decay mode $\eta' \rightarrow \pi^+\pi^-\eta$ is observed. The reaction $\pi^+n \rightarrow p\eta'$ is studied by using the spectator model. The cross section for $\pi^+n \rightarrow p\eta'$ is observed to rise to a maximum of about 100 $\mu$b at 2.2 GeV c.m. energy. The production angular distribution develops peripheral peaking with increasing energy. (auth)

18079 UPPER LIMITS ON RARE TWO-BODY PROCESSES IN $K^-$-p AND p-p SCATTERING AT HIGH ENERGIES. Birnbaum, D. (Carnegie-Mellon Univ., Pittsburgh); Edelstein, R. M.; Hien, N. C.; (and others). Phys. Lett.; 31B: 36-9(5 Jan 1970).

A missing-mass spectrometer search was made for several two-body, double-charge-exchange reactions, including backward $K^-p$ and $\bar{p}p$ elastic scattering at 8 and 16 GeV/c and small momentum transfer. No examples of any of these processes were observed. (auth)

18080 RESONANCE PRODUCTION IN $\pi^-p \rightarrow \pi^-\pi^-\pi^+p$ AT 6.7 GeV/c. von Krogh, Juergen Rudolph. Boulder, Colo.; Univ. of Colorado (1969). 110p.

Thesis.

Resonance production in the reaction $\pi^-p \rightarrow \pi^-\pi^-\pi^+p$ at a beam momentum of 6.7 GeV/c was studied in the 30 inch MURA hydrogen bubble chamber from a total of 100,000 exposures. The cross section for the above reaction was determined as $\sigma = (1.3 \pm 0.2)$ mb. As expected at this energy, high peripherality was noted. Bosons produced are $A_1(1060)$, $A_{1.5}(1180)$ and $A_2(1305)$, mainly decaying into $\pi^-p^0$, and $A_3(1640)$, mainly decaying into $\pi^-f^0$. These A-mesons cannot be explained away with low mass enhancements due to one-particle exchange diagrams. Isospin I = 1 is favored, g-parity is negative. A spin-parity analysis, fitting decay-angular distributions, was made. Spin-parity for the $A_1$ is consistent with $1^+$; for the $A_{1.5}$ $0^-$ and $2^+$ can be ruled out; spin-parity for the $A_2$ is consistent with 2+, however, $1^+$ and $2^-$ cannot be excluded. Baryons produced are N(1525) and N(1688), mainly going into $\pi^-\Delta^{3+}$. Isospin I = ½ is favored. The width for the N(1688) seems to be lower than generally obtained from phase shift analysis. (Diss. Abstr.)

18081 MEASUREMENT OF THE $\pi^-p \rightarrow n\gamma$ DIFFERENTIAL CROSS SECTION NEAR THE ROPER RESONANCE, $P_{11}(1460)$. Berardo, P. A. (Univ. of California, Los Angeles); Haddock, R. P.; Nefkens, B. M. K.; Verhey, L. J.; Zeller, M. E.; Parsons, A. S. L.; Truoel, P. Phys. Rev. Lett.; 24: 419–22(23 Feb 1970).

Six differential cross sections for $\pi^-p \rightarrow n\gamma$ were measured at 490-MeV/c incident $\pi^-$ momentum. The data do not agree with recent theoretical predictions. No evidence is found, in the sense suggested by Donnachie, for the classification of the Roper resonance, $P_{11}(1460)$, in an SU(3) antidecuplet. The angular distribution is consistent with the classification of the Roper resonance in an octet, as predicted by the simplest quark models. Using detailed balance, the results agree well with the reported cross sections for the inverse reaction, which are deduced from $\gamma$d data. (auth)

18082 PION–DEUTERON ELASTIC SCATTERING AND BREAK UP AT 3.65 BeV/c. Hsiung, Hsien-chih. Ann Arbor, Mich.; Univ. of Michigan (1969). 139p.

Thesis.

An experimental and theoretical investigation of pion-deuteron elastic scattering and deuteron break up reaction is presented. The differential cross section for the elastic scattering of positive pions from deuterons at 3.65 BeV/c was measured. Measurements were made for $-t$, the four momentum transfer squared, in the range 0.043–1.0 (BeV/c)$^2$. The data were obtained in a 222,000 picture exposure of the 20-inch deuteron bubble chamber at Brookhaven National Laboratory AGS. Experimental results are compared with calculations based on the Glauber high-energy approximation, utilizing the total $^3S_1 + {}^3D_1$ deuteron wave function and pion-nucleon scattering amplitudes. The experimental data do not show evidence for a pronounced dip. The agreement between experimental data and theoretical prediction is good. The differential cross section for the deuteron break up reaction, $\pi^+ + d \rightarrow \pi^+ + p + n$, at 3.65 BeV/c was also measured for $-t$ in the range 0.0625–0.30 (BeV/c). A theoretical prediction, based on Glauber's approximation, was calculated for a particular final state, $E_p = E_n$, and compared with the experimental results. (Diss. Abstr.)

18083 TWO-NUCLEON INTERACTIONS OF $K^-$ MESONS IN DEUTERIUM. Veirs, Val Rhodes. Chicago; Illinois Inst. of Tech. (1969). 93p.

Thesis.

The two nucleon interactions of $K^-$ mesons stopping in a deuterium bubble chamber are studied in the following channels: $K^- + d \rightarrow \Sigma^- + p$, $K^- + d \rightarrow \Sigma^0 + n$, and $K^- + d \rightarrow \Lambda + n$. The production rates relative to all stopping $K^-$ interactions and the two nucleon interaction branching ratios are measured. These rates are used to test existing models for the $K^-$ deuterium two nucleon interaction and to test charge independence of the nuclear forces. (Diss. Abstr.)

18084 SIX- AND SEVEN-PARTICLE FINAL STATES IN PION–DEUTERON INTERACTIONS AT 3.65 BeV/c. Fisher, Anthony Rankin. Ann Arbor, Mich.; Univ. of Michigan (1969). 171p.

Thesis.

An analysis of the meson and isobar states of reactions (1) $\pi^+d \rightarrow pp_s\pi^+\pi^+\pi^-\pi^-$ and (2) $\pi^+d \rightarrow pp_s\pi^+\pi^+\pi^-\pi^-\pi^0$ is presented. The data were obtained by studying 250,000 pictures of $\pi^+$d interactions in the 20-inch bubble chamber at an incident momentum of 3.65 BeV/c. Reaction (1) is dominated by $\rho^0$ and $N^*_{(3,3)}(1238)$ resonances, while reaction (2) contains a considerable amount of the $\omega$ and $N^*_{(3,3)}(1238)$ resonances. Also contained in reaction (2) are enhancements in the five pion system ($\pi^+\pi^+\pi^-\pi^-\pi^0$) which appear in the $\eta'(958)$, A2(1300), are R(1700) regions. Attempts were made to determine the spin-parity of the enhancement in the A2(1300) region, and to resolve the structure of the enhancement within the R(1700) region. A comparison is made between reaction (1) and its equivalent charge-symmetric reaction (3) $\pi^-p \rightarrow n\pi^+\pi^+\pi^-\pi^-$ concerning resonance production and cross sections. The degree of participation of the spectator proton ($p_s$) in reactions (1) and (2) is discussed by comparing the results with the impulse model and Hulthen theory. Also, the effects of Glauber screening and Pauli Exclusion are discussed. (Diss. Abstr.)

18085 LAMBDA HYPERON–K MESON PRODUCTION IN PION–PROTON COLLISIONS NEAR THRESHOLD. Jones, James Jordan. Tucson, Ariz.; Univ. of Arizona (1969). 78p.

Thesis.

The reaction $\pi^- + p \rightarrow \Lambda^0 + K^0$ was studied in the incident pion momentum interval from 0.89 to 1.13 GeV/c using an external pion beam from the Berkeley Bevatron impinging on a liquid hydrogen target. Examples of this reaction were selected from other

possible final states on the basis of a predetermined signature in a system of scintillation counters. Events thus selected were analyzed by means of optical spark chambers which provided information on the trajectories of the incident pion and the charged decay products of the $\Lambda^0$ or $K^0$. Also, for each such event, the incident pion momentum was measured to approximately 1 MeV/c using a spark chamber spectrograph located in the incident pion beam. Using this technique, 835 events were obtained in the region near threshold for this reaction and 12,845 events were obtained in the region of incident pion momentum corresponding to the thresholds for the reactions $\pi^- + p \rightarrow \Sigma^0 + K^0$ and $\pi^- + p \rightarrow \Sigma^- + K^+$. Analysis of the events near threshold indicates pure s-wave $\Lambda^0 + K^0$ production immediately above threshold and substantial p-wave contribution when the center of mass momentum reaches 100 MeV/c. Examination of events in the region of the ΣK thresholds shows no striking evidence of cusp-like structure in any of the production parameters due to the onset of these alternate channels. However, some evidence was obtained for anomalous structure with a characteristic width of 2 to 3 MeV/c which appears unrelated to the existence of the ΣK thresholds. (Diss. Abstr.)

**18086** Λ FINAL STATES FROM INTERACTION OF $K^-$ MESONS ON DEUTERIUM AT 4.5 GeV/c. Yen, Wen Liang. Lafayette, Ind.; Purdue Univ. (1969). 113p.

Thesis.

The results presented were obtained from an analysis of 372,000 $K^-d$ bubble chamber pictures at an incident $K^-$ momentum at 4.5 GeV/c. The main emphasis was on the two body final states, such as $\pi^-\Lambda$, $\pi^-\Sigma^0$, $\rho^-\Lambda$, $\pi^0 Y_1^{*-}(1385)$, $\delta^-\Lambda$, $Y_1^{*-}(1385)\eta$, and $Y_1^{*-}(1660)\eta$. The differential cross section and polarization of the Λ hyperon in the reaction $K^-n \rightarrow \pi^-\Lambda$ was determined and compared with the double-Regge-pole model of Reeder and Sarma. The model predicts the differential cross section quite accurately and a dip occurs in the experimental distribution near $t = -0.4$ (GeV c)$^2$. The polarization was found to be large and remains more or less constant with a value $0.6 \pm 0.2$. No change in sign was observed in contrast with the prediction of the model of Reeder and Sarma. A common feature of the observed two body final states is that their production process is dominated by a peripheral mechanism which arises from meson exchange processes. The exchange mechanism for the reaction $K^-n \rightarrow \rho^-\Lambda$ was investigated in terms of the density matrix formalism. It was found that more than one exchange contributes to the production of this final state. The $\delta^-$ meson was observed in the reaction $K^-n \rightarrow \delta^-\Lambda$. The decay mode observed was $\delta^- \rightarrow \pi^-\eta$. The mass observed is 975 MeV with a width of about 130 MeV. The isospin was unambiguously determined to be one. The spin and parity favors $0^+$. The observed properties were very similar to that found in the BNL–Syracuse collaboration in the reaction $K^-p \rightarrow A\pi^+\delta^-$ at 4.6 BeV/c incident $K^-$ momentum. (Diss. Abstr.)

**18087** ESTIMATION OF THE UPPER BOUNDARY OF CROSS SECTION FOR π MESON CHARGE EXCHANGE ON CARBON NUCLEI. Abdullaeva, K. N.; Azimov, S. A.; Grishin, V. G.; Rizaev, Kh. A.; Yuldashev, A. A.; Yuldashev, B. S. (Inst. of Nuclear Physics, Tashkent). Dokl. Akad. Nauk Uzb. SSR; No. 4, 13-14(1969). (In Russian).

Reactions of $\pi^- + {}^{12}C \rightarrow {}^{12}B + m\pi^0$ with (m = 1, 2...) were studied using a 24-liter propane bubble chamber irradiated with $\pi^-$ mesons of 4 GeV/c. The measurements of the cross sections for the reaction were equal to 4μ barn per event. Thus, with the 95% probability the upper boundary of the reaction must be equal to 120 μ barn. (R.V.J.)

**18088** ASYMMETRY PARAMETER AND BRANCHING RATIO OF $\Sigma^+ \rightarrow p\gamma$. Gershwin, Lawrence K.; Alston-Garnjost, Margaret; Bangerter, Roger O.; Barbaro-Galtieri, Angela; Mast, Terry S.; Solmitz, Frank T.; Tripp, Robert D. (Univ. of California, Berkeley). Phys. Rev.; 188: 2077-80(25 Dec 1969).

An experiment to study the decay $\Sigma^+ \rightarrow p\gamma$ was performed in the Berkeley 25-in. hydrogen bubble chamber. An analysis was made of 46,000 events of the type $K^-p \rightarrow \Sigma^+\pi^-$, $\Sigma^+ \rightarrow p$ + neutral with $K^-$ momenta near 400 MeV/c. The Σ's produced in this momentum region are polarized because of the interference of the $Y_1^*(1520)$ amplitude with the background amplitudes. The proton asymmetry parameter α was measured for 61 $\Sigma^+ \rightarrow p\gamma$ events with an average polarization of 0.4. Alpha $= -1.03^{+0.39}_{-0.32}$ was found. SU(3) predicts a value $\alpha = 0$. A more restricted sample of events was used to determine the $\Sigma^+ \rightarrow p\gamma$ branching ratio. From 31 $\Sigma^+ \rightarrow p\gamma$ events and 11,670 $\Sigma^+ \rightarrow p\pi^0$ events, $(\Sigma^+ \rightarrow p\gamma)/(\Sigma^+ \rightarrow p\pi^0) = (2.76 \pm 0.51) \times 10^{-3}$ was found. The result is in agreement with the previous measurements. (auth)

**18089** COHERENT PRODUCTION OF THE $K^-\pi^+\pi^-$ SYSTEM IN $K^-$–d INTERACTIONS AT 5.5 GeV/c. Werner, B. (Northwestern Univ., Evanston, Ill.); Ammar, R.; Davis, R. E. P.; Kropac, W.; Yarger, H.; Cho, Y.; Derrick, M.; Musgrave, B.; Phelan, J. J.; Wangler, T. P. Phys. Rev.; 188: 2023-33 (25 Dec 1969).

$K^-d$ interactions were studied at an incident momentum of 5.5 GeV/c in a 5-eV/μb exposure of the 30-in. deuterium bubble chamber at the Argonne Zero-Gradient Synchrotron. The dominant feature of the reaction $K^-d \rightarrow K^-\pi^+\pi^-d$ is $K^*(890)$ production, although the low-mass enhancement, usually referred to as $d^*$, is also prominent in the $d\pi^-$ mass spectrum. The low momentum transfer to the deuteron imposed by coherent production strongly favors a $K\pi\pi$ mass in the region of the Q enhancement. As is usually observed, the production and decay characteristics of the $K\pi\pi$ system are generally compatible with a $1^+$ spin-parity assignment. A study of the $K^-\pi^+$ system reveals an s-wave–p-wave interference similar to that observed in $K\pi$ scattering. The data are compared with the predictions of a double-Regge-pole model. (auth)

**18090** FINAL STATES WITH A SINGLE CHARGED PARTICLE AND VISIBLE Λ FROM $K^-n$ INTERACTIONS AT 4.5 GeV/c. Yen, W. L.; Ammann, A. C.; Carmony, D. D.; Eisner, R. L.; Garfinkel, A. F.; Gutay, L. J.; Kramer, S. L.; Miller, D. H. (Purdue Univ., Lafayette, Ind.). Phys. Rev.; 188: 2011-23(25 Dec 1969).

The results presented in this paper were obtained from an analysis of 372,000 $K^-d$ bubble-chamber pictures at an incident $K^-$ momentum of 4.48 GeV/c. The results on two-body final states, such as $\pi^-\Lambda$, $\pi^-\Sigma^0$, $\rho^-\Lambda$, $\pi^-\Sigma^0(1385)$, $\pi^0\Sigma^-(1385)$, $\pi N^-(980)\Lambda$, $\eta\Sigma^-(1385)$ are reported. The polarization of the Λ hyperon in the reaction $K^-n \rightarrow \pi^-\Lambda$ was determined and compared with the double-Regge-pole model of Reeder and Sarma. The polarization is large and remains more or less constant. No change in sign was observed, in contrast with the prediction of the model of Reeder and Sarma. A common feature of the observed two-body final states is that their production process is dominated by a peripheral mechanism which arises from meson exchange processes. The exchange mechanism for the reaction $K^-n \rightarrow \rho^-\Lambda$ was investigated in terms of the density matrix formalism. It was found that more than one exchange contributes to the production of this final state. The $\pi N^-(980)$ meson was observed in the reaction $K^-n \rightarrow \pi N^-\Lambda$. The decay mode observed was $\pi^-N \rightarrow \pi^-\eta$. The mass observed is $0.98 \pm 0.01$ GeV with a width of $0.06 \pm 0.03$ GeV. (auth)

**18091** STUDY OF THE INTERACTION $\pi^- + P$ yields $N + 2\pi^0$ AT 1.53 AND 1.27 BeV/c. Gleeson, Ronald Francis. Philadelphia; Univ. of Pennsylvania (1969). 82p.

Thesis.

The observation of an S-wave $\pi^0\pi^0$ enhancement at 715 MeV of width 150 MeV by the study of the reaction $\pi^- + p \rightarrow n + 2\pi^0$ is reported. The momentum of the neutron was measured by the time of flight technique, and lead plate spark chambers were used to determine the four gamma ray directions. (Diss. Abstr.)

**18092** THREE-PION PRODUCTION PROCESSES IN 6.7 GeV/c $\pi^-p$ INTERACTIONS. Miyashita, Shigeyuki. Boulder, Colo.; Univ. of Colorado (1969). 260p.

Thesis.

The final states $\pi^-\pi^-\pi^+\pi^0p$ and $\pi^-\pi^-\pi^+\pi^+n$ from 6.7 GeV/c $\pi^-p$ interactions in the 30-inch Argonne bubble chamber are studied. The complexity of these reactions is largely reduced by resonance productions in the intermediate states, which amounts to more than fifty percent of the reactions leading to these two final states. Dominant resonance states found in the data are ρ(760), ω(780), and Δ(1236). In studying the invariant mass distributions, phase space is found to be a good first approximation to account for the shape of the distributions. The data were fitted reasonably well by the incoherent superposition of phase space and the resonant amplitudes. For well-established resonances, resonance parameters (mass and width) thus obtained, are consistent with accepted values. Many higher boson resonances and nucleon isobars are found to be associated closely to the lower resonance states. It is found that the analog state represents an adequate background for the higher resonance study. The A mesons, B meson, g′ meson, and N(1710) as well as N(1518) are studied in this manner in some detail. Associated resonance productions are rather copious, which leads to the quasi three-body final states. It is found, however, that a mere statistical coincidence of two independent single-resonance productions can account for most quasi three-body final states; thus, no strong correlations between two resonance productions are noted. The production-angle distributions for pions and nucleon show strong correlations between the pion and the nucleon but very weak correlations among pions. (Diss. Abstr.)

**18093** EXPERIMENTAL STUDY OF $K^-p$ CHARGE EXCHANGE AT 1.8 BeV/c. Sossong, Norman Dale. St. Louis; Univ. of Washington (1969). 228p.

Thesis.

The angular distribution in the center of mass for $K^-p$ charge exchange was measured at an incident $K^-$ beam momentum of

1.8 BeV/c (785 MeV/c in the center of mass). Scintillation and gas Cherenkov counters and optical spark chambers were used for detectors; liquid hydrogen provided the target protons. The angular distribution is strongly peaked for forward $K^0$'s with no evidence for a dip at 0°. The angular distribution was fitted to a Legendre polynomial series and the coefficients calculated. Angular momenta up to and including l = 5 are necessary to account for the data. A modified form of $\rho$-exchange is found to fit the data quite well in the forward direction. (Diss. Abstr.)

**18094** COHERENT PRODUCTION IN $K^-d$ INTERACTIONS AT 12.6 GeV/c. Denegri, Daniel Ivan. Baltimore; Johns Hopkins Univ. (1969). 216p.

Thesis.

Coherent production is observed in $K^-d$ interactions at 12.6 GeV/c incident momentum. The Q(1300) and L(1750) mesons are observed in the $K^-\pi^+\pi^-$ system of the preponderant channel, $K^-d \rightarrow K^-\pi^+\pi^-d$. This is the first observation of high energy coherent productions induced by K mesons, and the first observation of L meson production on nuclei. The isospin of the Q and L objects are unambiguously determined to be ½. A striking resemblance between the final states $K^*(890)\pi d$ and $K^*(1420)\pi d$ is observed, with these final states being related to the Q and L objects respectively. Partial decay rates of the Q and L are discussed. The spin properties of the Q and L are investigated. The Q is found to be most likely a $1^+$ system with a dominant S wave $K^*\pi$ decay mode, while the L a $2^-$ or a $1^+$ system. Direct coherent production of the $K^*(890)$ is observed at a very low rate. Cross sections for various coherent production channels are determined. (Disser. Abstr.)

**18095** BACKWARD PION–PROTON ELASTIC SCATTERING FROM 6 TO 17 GeV/c. Owen, Daniel Pitkin. Ithaca, N. Y.; Cornell Univ. (1969). 146p.

Thesis.

The angular distribution of pion-proton elastic scattering was measured near the backward direction using both positive and negative pions incident on a liquid hydrogen target. Measurements were made covering the angular range $180° \geq \theta_{CM} \geq 140°$ using both positive and negative pions with incident momenta of 6 and 10 GeV/c. In addition, the scattering in the angular range $180° \geq \theta_{CM} \geq 165°$ was measured using negative pions with 14 and 16 GeV/c incident momenta and positive pions with 17 GeV/c incident momenta. The scattered pions and recoil protons were momentum analyzed in bending magnets and detected in scintillation counter telescopes. Optical spark chambers were used to more precisely determine the position and direction of the particles' trajectories. For both positive and negative pion-proton scattering, the cross section was found to rise by over two orders of magnitude in the backward direction. The results confirmed the presence of a sharp dip in the positive pion-proton scattering cross section at $u = -0.13$ (GeV/c)$^2$; while the negative pion-proton scattering cross section was found to be smoothly varying over the angular range covered. The results are briefly discussed in light of the predictions of a simple Reggeized baryon exchange model. (Diss. Abstr.)

# Particle Interactions and Properties (Theoretical)

## General

*Refer also to abstracts 17190, 18060, 18128, and 18298.*

**18096** (CERN–69-29) PROCEEDINGS OF THE 1969 CERN SCHOOL OF PHYSICS, LEYSIN, AUGUST 31–SEPTEMBER 13, 1969. (European Organization for Nuclear Research, Geneva (Switzerland)). Jan 1970. 208p. Dep. CFSTI (U. S. Sales Only).

Eight lectures were included. Separate abstracts were prepared for each lecture. (J.F.P.)

*For abstracts of individual lectures see: 16879–16881, 18059, 18106, 18149, 18184, and 18314.*

**18097** (IS–2100, Sect. P) PHYSICS DIVISION. Hansen, R. S.; Zaffarano, D. J.; Barnes, R. G.; (and others) (Ames Lab., Iowa). 73p.

Research in the fields of high energy physics, medium energy physics, low energy physics, crystal physics, superconductivity, and magnetic materials is briefly outlined. Most of the research summaries are abstracts of articles submitted for journal publication. (C.E.S.)

**18098** REGGEIZED DIFFERENTIAL CROSS SECTIONS IN A COVARIANT FORMALISM. Gault, F. D. (Univ. of Durham, Eng.); Scadron, M. D. Nucl. Phys.; B15: 442–50(1970).

A scheme is developed for calculating Reggeized spin-averaged differential cross section directly from the Regge vertices and the results are tabulated. Photonic vertex couplings for boson exchange are also derived. (auth)

**18099** GENERAL SUM RULES FROM CURRENT-DENSITY ALGEBRA. Montvay, I. (Roland Eoetvoes Univ., Budapest). Acta Phys. Acad. Sci. Hung.; 26: 345–52(1969).

Current density algebra sum rules for three- and four-point functions are investigated under the assumption of multiple integral representations of current correlation functions in the currents' masses. It is proved that the sum rules corresponding to a limit to infinite momentum in an arbitrary linear combination of momenta ($P_0 \rightarrow \infty$, $\Delta_0 \rightarrow \infty$ etc.) collapse into a single sum rule. (auth)

**18100** NONCAUSALITY AND OTHER DEFECTS OF INTERACTION LAGRANGIANS FOR PARTICLES WITH SPIN ONE AND HIGHER. Velo, Giorgio; Zwanzinger, Daniel (New York Univ., N. Y.). Phys. Rev.; 188: 2218–22(25 Dec 1969).

A critical analysis was made of what happens when various interaction terms are added to a Lagrangian describing a free particle with spin ≥1. Good behavior results when the charged spin-one particle is coupled minimally to an external electromagnetic field or via a magnetic dipole moment. However, with an arbitrary electric quadrupole moment, the spin-one particle propagates noncausally (v > c) in an electrostatic field. Noncausal behavior is also found for the neutral vector field with self-coupling $\lambda(W_\mu W^\mu)^2$. Another kind of disease appears when the spin-two particle is given a charge: A constraint is converted into an equation of motion, so that there are six degrees of freedom instead of the desired five. (auth)

**18101** THEORY AND PHENOMENOLOGY IN PARTICLE PHYSICS. PART B. 1968 International School of Physics Ettore Majorana, a MPI–NATO Advanced Study Institute, Erice, [Switzerland], July 13–28, 1969. Zichichi, A. (ed.). New York; Academic Press Inc. (1969). 493p.

The 13 lectures are separately abstracted for NSA. (C.E.S.)

*For abstracts of individual lectures see: 18070, 18138, 18158, 18180, 18213, 18230, 18253, 18254, 18260, 18278, 18308, 18309, and 18340.*

**18102** NONLOCAL POTENTIALS AND TWO-BODY SCATTERING. Leeman, S. (Oxford Univ.). Proc. Roy. Soc. (London), Ser. A; 315: 49–67(3 Feb 1970).

It is shown that in elastic collisions between spinless particles a nonlocal, i.e., velocity dependent, potential is uniquely determined by the knowledge of the scattering amplitude for all angles and a range of energies, provided the potential is assumed to be of a form discussed by Wong (1963) (which means that, in a certain sense, it has no explicit dependence on angular momentum) and also subject to certain, rather weak, restrictions on the analytic properties of the potential. The case of spin ½ particles is also discussed briefly. (auth) (UK)

**18103** HYPERPLANE FORMALISM AND APPLICATION TO THEORY OF ELEMENTARY PARTICLES. McDonald, Stanley Clifton. Iowa City, Iowa; Iowa State Univ. (1969). 74p.

Thesis.

The principle of covariance as applied to the theory of elementary particles is further exploited by extending Fleming's hyperplane formalism to include a discussion of the operations of the Poincaré group as seen by an arbitrary hyperplane observer. The hyperplane generalization of the infinitesimal generators of the connected part of the Poincaré group are constructed by performing a Lorentz transformation on the canonical generators, and are seen to be those operators previously defined by Fleming. Helicity basis states for the $m^2 > 0$ irreducible representations of the Poincaré group are reexpressed within the framework of generalized covariance provided by the hyperplane formalism, and are seen to be related to the conventional helicity states of Jacob and Wick by a special Lorentz transformation. In a similar fashion, the canonical states constructed by Foldy are generalized to an arbitrary hyperplane. The localized states of Newton and Wigner are reconstructed as a superposition of the canonical states, and these states are also generalized to an arbitrary hyperplane via a procedure similar to that used for the hyperplane generalization of the helicity and canonical states. The corresponding position operator, with mutually commuting components, is then constructed, and is seen to be equivalent to that operator given by Fleming. (auth)

**18104** HIGH ENERGY PHYSICS INDEX, VOLUME 8, NOS. 1–3, 2 FEB. 1970. Frankfurt am Main; Zentralstelle fuer Atomkernenergie-Dokumentation (1970). 112p.

18105 HIGH ENERGY PHYSICS INDEX. VOLUME 7, NO. 26, 1969. Frankfurt am Main; Zentralstelle fuer Atomkern-energie-Dokumentation (1969). 56p.

## Electromagnetic

*Refer also to abstracts 18194 and 18247.*

18106 (CERN-69-29, pp 47-60) INTRODUCTION TO PHOTOPRODUCTION. Lohrmann, E. (Deutsches Elektronen-Synchrotron, Hamburg (West Germany)).

A general framework of photoproduction is presented. The general matrix element for photoproduction, gauge invariance, current-field identity, isospin, and SU(3) symmetry are discussed. (J.F.P.)

18107 (CNRS-CPT-69-P-311) GROUP-THEORETICAL ANALYSIS OF ELEMENTARY PARTICLES IN AN EXTERNAL ELECTROMAGNETIC FIELD. I. THE RELATIVISTIC PARTICLE IN A CONSTANT AND UNIFORM FIELD. Bacry, H.; Combe, Ph.; Richard, J. L. (Centre National de la Recherche Scientifique, Marseilles (France). Centre de Physique Theorique). [1967]. 58p. Dep. CFSTI (U. S. Sales Only).

Two subgroups of the Poincaré group are shown to play a particular role in the case of charged systems in an external electromagnetic field which is constant and uniform. Projective representations of these subgroups involve the electric charge as a generator of a phase factor. Additivity and superselection rules for charge appear as direct consequences. (auth)

18108 (CONF-690330-, pp 36-46) THEORETICAL STUDY OF THE REACTIONS $e^+e^- \to \pi^+\pi^-\gamma$ AND $e^+e^- \to \pi^+\pi^-\pi^0\pi^0$. Renard, F. M. (Montpellier Univ. (France). Faculte des Sciences). (In French).

A theoretic study of the interaction $e^+ + e^- \to \pi^+ + \pi^- + \gamma$ is given and includes general properties, a model for $\rho^0 \to \pi^+ + \pi^- + \gamma$, decay and spectra and total cross sections. Also studied is the interaction $e^+ + e^- \to \pi^+ + \pi^- + 2\pi^0$. This study covers the general properties, and a model for $\rho^0 \to \pi^+ + \pi^- + 2\pi^0$ decay. (J.F.P.)

18109 (CONF-690330-, pp 48-60) VECTOR DOMINANCE AND VECTOR MESON PHOTOPRODUCTION. Stodolsky, L. (Paris Univ., Orsay (France). Laboratoire de Physique Theorique et Hautes Energies).

The discussion of the photoproduction of neutral vector mesons covers the qualitative aspects of proton and neutral vector meson production in $\gamma + p$ interactions, coupling constants, determination of the coupling constants from photoproduction, unitarity constraint, and a relation for the total cross section. (J.F.P.)

18110 (CONF-690330-, pp 152-60) COHERENT PRODUCTION. Grivaz, J. F. (Paris Univ., Orsay (France). Laboratoire de l'Accelerateur Lineaire). (In French).

The Glauber model and coherent production are discussed. Also applications to photoproduction, hadroproduction, and the meson ($A_1$) are considered. (J.F.P.)

18111 (CONF-690330-, pp 161-4) BEHAVIOR OF THE HELICITY AMPLITUDE IN THE t CHANNEL. Capella, A. (Paris Univ., Orsay (France). Laboratoire de Physique Theorique et Hautes Energies). (In French).

Two-body interactions are considered in the study of the helicity amplitude behavior in the t channel. Formulas are valid in the case of the exchange of either a boson or a baryon trajectory. These formulas are also valid when a massless particle is present in the initial state and/or final state of the t channel. The interactions $\gamma + N \to \pi + \Delta(N)$ and $\pi + N \to \rho + \Delta$ are discussed to illustrate these formulas. (J.F.P.)

18112 (ITF-69-85) TWO-BODY COULOMB SINGULARITIES IN THE EQUATIONS FOR THREE CHARGED PARTICLES. Veselova, A. M. (Akademiya Nauk Ukrainskoi SSR, Kiev. Institut Teoreticheskoi Fiziki). 1969. 10p. (CONF-690632-4). Dep. CFSTI (U. S. Sales Only).

From Conference on the Theory of Small-Nucleon Systems, Kiev, USSR.

The system of three charged particles is considered. The regular system of the integral equations for the bound state scattering problem below the ionization threshold is obtained. The kernels of these integral equations are expressed in terms of the solutions of two-body problems only. (auth)

18113 (ITF-69-88) TWICE-LOGARITHMIC ASYMPTOTIC BEHAVIOR OF THE AMPLITUDE OF ANNIHILATION $e^+e^- \to n\gamma$. Kuraev, E. A.; Kalinichenko, A. F. (Akademiya Nauk Ukrainskoi SSR, Kiev. Institut Teoreticheskoi Fiziki). 1969. 14p. (In Russian). Dep. CFSTI (U. S. Sales Only).

An expression is obtained for the asymptotic behavior of the amplitude of annihilation of an electron-positron pair in an arbitrary number of photons at high energies in the center-of-mass system providing that two hard photons in a finite state which carry almost all energy of the pair are emitted in the direction of the initial particles and the remaining photons are emitted arbitrarily; the photons are polarized perpendicular to momenta $e^+e^-$. (auth)

18114 (ITF-69-92) EVALUATION OF THE DEUTERON QUADRUPOLE MOMENT BY np- AND pp-SCATTERING. Savchenko, O. Ya. (Akademiya Nauk Ukrainskoi SSR, Kiev. Institut Teoreticheskoi Fiziki). 1969. 32p. (In Russian). Dep. CFSTI (U. S. Sales Only).

A consideration is made of potential scattering of slow Dirac particles in the presence of the S – level (an analog of the Wigner scattering of spinless particles). The analysis of scattering is carried out according to Zauter. To determine the observed quantities the method of introducing of quantities by the hypercomplex dividers is used. The obtained results are used to estimate the deuteron quadrupole moment according to the data of np- and pp-scattering in the range of 20 to 200 MeV. (auth)

18115 EFFECTS OF $SU_3$ VIOLATION ON BARYON ELECTROMAGNETIC PROPERTIES. Divakaran, P. P. (Tata Inst. of Fundamental Research, Bombay). Nucl. Phys.; B15: 601-16 (1970).

An attempt is made to calculate the deviations of the baryonic electromagnetic form factors for small t from the Coleman-Glashow predictions by assuming that $SU_3$ is an asymptotically exact symmetry. This assumption leads to superconvergence relations for linear combinations of form factors, which are then saturated by the $\rho$, $\omega$, and $\phi$ mesons. For the Dirac form factors a complete determination of the couplings of these mesons to all baryons is obtained. In the case of the Pauli form factors, estimates of the magnetic moments based on the mixing phenomenology give corrections to the $SU_3$ values which are quite large for $\Lambda$ and $\Xi^-$. It is shown that the final results are quite stable with respect to large changes in the parameters deduced from mixing. For the two baryon moments measured so far, $\mu(\Lambda) = -0.64$ and $\mu(\Sigma^+) = 2.61$ proton magnetons. (auth)

18116 COULOMB DISINTEGRATION OF $\Lambda$-$H^3$ IN NUCLEAR EMULSION. Bohm, G.; Wysotzki, F. (Institut fuer Hochenergiephysik, Berlin). Nucl. Phys.; B15: 628-36(1970).

The decay of ${}_\Lambda H^3$ caused by electromagnetic interaction with nuclei is studied. Its effect on measurements of the mean lifetime of ${}_\Lambda H^3$ in nuclear emulsion is calculated. (auth)

18117 ON THE ANALYSIS OF VECTOR-MESON PRODUCTION BY POLARIZED PHOTONS. Schilling, K. (California Inst. of Tech., Pasadena); Seyboth, P.; Wolf, G. Nucl. Phys.; B15: 397-412(1970).

The formalism necessary to analyze production of vector mesons with polarized photons ($\gamma p \to pV$) is presented in detail. The decay angular distribution of the vector mesons is parameterized by the density matrices $\rho^\alpha$, $\alpha = 0, 1, 2, 3$. Restrictions on the numerical values of the density matrix elements are derived. From the symmetry properties of the helicity amplitudes, it is shown that at high energies the combinations $\rho^0_{\lambda\lambda'} \mp (-1)^\lambda \rho^1_{\lambda\lambda'}$ to leading order in energy receive only contributions from natural (unnatural) parity exchange in the t-channel. It is shown that this is true in any coordinate system which can be reached from the vector-meson helicity system by a rotation around the normal to the production plane. The values of the density matrices as predicted by various models: elementary $0^\pm$ exchange, spin independence, helicity conservation, are given. (auth)

18118 VENEZIANO MODEL FOR K-MESON DECAYS. Toda, Azuma (Tohoku Univ., Sendai). Progr. Theor. Phys. (Kyoto); 42: 1349-60(Dec 1969).

The decay amplitude of K-meson is investigated on the basis of the Veneziano model and our model is examined by comparing its result with that of the effective chiral Lagrangian. The Veneziano amplitudes are constructed for $\pi K \to \pi K_A$ and $\pi K \to \pi K^*$ scatterings. Then, (I) the form factors in the $K_{l4}$ decay are explicitly given by correlating them with the scattering $\pi K \to \pi M (M = K, K_A$ and $K^*)$; (II) the decay amplitude for $K_{3\pi}$ is also given by correlating it with the scatterings $\pi$-$\pi$, $\pi$-K, $\pi\pi \to \pi A_1$ and $\pi K \to \pi K_A$ and (III) there are some remarks on the $K_{2\pi}$ and $K_{l2}$ decays. In the approximation of the Veneziano amplitude to the first order of s, t, and u, the contributions of $\pi$-K and $\pi$-$\pi$ scatterings to the form factors in $K_{l4}$ and the decay amplitude for $K_{3\pi}$ take the same forms as those of the chiral Lagrangian. The contributions of $\pi K \to \pi K_A$

and $\pi\pi \to \pi A_1$ scatterings depend on the values of $g^{(a)}$ and $g^{(a_1)}$ which are, in principle, determined by the coupling constants, and also whether or not the $\sigma$- and $\kappa$-mesons should be neglected. (auth)

**18119** A MODEL FOR THE ELECTROMAGNETIC FORM FACTORS OF NUCLEONS. Kobayashi, Masanori (Hiroshima Univ.). Progr. Theor. Phys. (Kyoto); 42: 1319-28(Dec 1969).

A model for the electromagnetic form factors of nucleons which have the dipole asymptotic behavior is proposed. The model consists of the contributions from the exchange of vector mesons appearing on infinite daughter trajectories. (auth)

**18120** BREAKDOWN OF THE SCALING LAW FOR THE NUCLEON ELECTROMAGNETIC FORM FACTORS. Narita, Takao (Tohoku Gakuin Univ., Tagajo, Japan). Progr. Theor. Phys. (Kyoto); 42: 1336-40(Dec 1969).

The breakdown of the scaling law for the nucleon electromagnetic form factors is discussed on the assumption that the charge and magnetic moment form factors have the same "isotopic" structure and the formulas which express how the scaling law breaks down are derived. It is shown that the breakdown of the scaling law is closely related to the nonvanishing neutron charge form factor. Considering the experimental data on the breakdown of the scaling law and the neutron charge form factor, it is predicted that the neutron charge form factor $G_E^n(q^2)$ should cross the $q^2$-axis around $q^2 = 0.2 \sim 0.6$ $(GeV/c)^2$. (auth)

**18121** VACUUM POLE IN QUANTUM ELECTRODYNAMICS. Frolov, G. V.; Gribov, V. N.; Lipatov, L. N. (Ioffe Inst. of Physics and Tech., Leningrad). Phys. Lett.; 31B: 34-5(5 Jan 1970).

The asymptotic behavior of the ee, $e\gamma$ and $\gamma\gamma$ scattering amplitudes is determined in the main logarithmic approximation. The j-plane singularities in the channel with vacuum quantum numbers are investigated near j = 1. (auth)

**18122** ELECTROMAGNETIC STRUCTURE OF THE NUCLEON. Kanazawa, Akira; Haruyama, Masahiro (Hokkaido Univ., Sapporo). Progr. Theor. Phys. (Kyoto); 42: 1487-9(Dec 1969).

A simple model is presented for the nucleon electromagnetic form factor, which has a form similar to the pion form factor derived by Sugawara where a spurion formalism was used in applying the Veneziano formula to the vortex. The model reproduces well the experimental data. (L.B.S.)

**18123** DOMAIN OF VALIDITY OF VECTOR-MESON DOMINANCE IN INELASTIC ELECTRON–PROTON SCATTERING. Cho, C. F.; Sakurai, J. J. (Univ. of California, Los Angeles. Univ. of Chicago). Phys. Lett.; 31B: 22-5(5 Jan 1970).

It is argued that the vector-meson dominance model for inelastic electron-proton scattering is more likely to succeed when $s \gg q^2$, e.g., $2m_p\nu/q^2 \gtrsim 10$. The model is compared in detail with the recently published 6 and 10° data of the SLAC-MIT experiment. (auth)

**18124** MOTION OF THE CENTER OF GRAVITY OF A WAVE PACKET CENTERED ACCORDING TO THE LARGE QUANTUM NUMBERS N,L FOR A MASS-M PARTICLE IN AN ATTRACTIVE COULOMB FIELD. Levy, Albert (Institut de Calcul Numerique, Toulouse). Compt. Rend., Ser. B; 269: 789-92(29 Oct 1969). (In French).

It is known that if one considers a wave packet centered according to large quantum numbers the matrix element $\langle N + k\ |1/r|\ N\rangle$ tends toward the $k^{th}$ harmonic of the Fourier series for the classical magnitude [1/r(t)]. The problem was studied previously for l = 0, it is proposed to do this analytically for any l. (tr-auth)

**18125** ELECTROMAGNETIC FORM FACTORS OF NUCLEONS IN $\nu + n \to e^- + p$ AND $\bar{\nu} + p \to e^+ + n$ REACTIONS. Kalinichenko, A. I.; Pyzh, V. M.; Rekalo, A. P. (Kharkov State Univ.). Ukr. Fiz. Zh.; 19: 1561-3(Sep 1969). (In Russian).

Energy functions of total cross sections and angular functions of differential cross sections of $\nu + n \to e^- + p$ and $\bar{\nu} + p \to e^+ + n$ reactions were calculated using new data on electromagnetic form factors of nucleons as functions of transmitted pulse square. Experiments using the case of $E_\nu = 2$ GeV revealed that the difference in differential cross section reaches 20% and the magnitude of cross sections in this region is $10^{-39}$ $cm^2$/ster. Data obtained confirmed the importance of selection of nucleon electromagnetic form factors in theoretical evaluation of $\nu n$-reactions. (R.V.J.)

**18126** EFFECTS OF B INTERACTION IN THE $e^- + e^+ \to \mu^- + \mu^+$. Gnedov, Yu. A. (Sterlitamak Teacher's Inst., USSR). Izv. Vyssh. Ucheb. Zaved., Fiz.; No. 1, 143-4(1969). (In Russian).

Published data showed that electron-positron pair can convert into a $\mu$-meson pair within the limits of an ordinary electromagnetic interaction. The unified model for single weak electromagnetic interactions indicated that interactions between two charged particles can be transmitted not only by the photons but also by heavy vector bosons which interact with axial currents of charged particles (the B-interaction). The existence of the B interaction effect during the $e^- + e^+ \to \mu^- + \mu^+$ process in an accelerator with colliding beams was verified. (R.V.J.)

**18127** PHOTON TRANSFORMATION INTO GRAVITON IN THE EXTERNAL MAGNETIC FIELD AND GRAVITON DECAY INTO A PAIR OF PHOTONS IN THE EXTERNAL GRAVITATIONAL FIELD. Poznanin, P. L. (Moscow State Univ.). Izv. Vyssh. Ucheb. Zaved., Fiz.; No. 10, 78-82(1969). (In Russian).

Photon-graviton transformation (and in reverse) processes in external electromagnetic and gravitational fields were studied. All formulas are written out in the unit system of $C = \hbar = 1$ except for the formulas for total cross sections given in the units of CGS. (R.V.J.)

**18128** EXISTENCE OF COVARIANT T PRODUCT OF CURRENTS AND ON FIXED J POLES IN PHOTOPRODUCTION PROCESSES. Lee, Shun-Yi. Princeton, N. J.; Princeton Univ. (1969). 102p.

Thesis.

The thesis consists of two parts which deal with two different subjects. In the first part the existence of the covariant T-product for any number of currents is studied without introducing the extraneous assumption that the currents have any connection with a gauge principle. The result obtained is that there always exists a covariant T-product for any number of currents, which can be constructed explicitly by an algebraic method. Furthermore, the divergences of this covariant T-product are, as expected, those which one would obtain from an ordinary T-product if Schwinger terms are consistently ignored. The second part of the thesis is on the fixed poles in the photoproduction process. A new argument, based on a potential theory model, claims that fixed poles are absent in the photoproduction process if the external particles lie on Regge trajectories. It is also pointed out that high energy, backward pion photoproduction is the best place to look for right signature fixed poles in the complex J-plane. (Diss. Abstr.)

**18129** COMPTON SCATTERING OF $\gamma$ QUANTA ON $^4$He NUCLEI. Alimov, A. D. (Inst. of Nuclear Physics, Tashkent). Izv. Akad. Nauk Uzb. SSR, Ser. Fiz.-Mat. Nauk; No. 5, 71-4(1969). (In Russian).

Most studies on the scattering of $\gamma$ quanta on very light nuclei have been carried out at energies below the generation of $\pi$ mesons. In order to remedy this, the phenomenon was studied with $^4$He nuclei in the range from the threshold of the generation of $\pi$ mesons upward, using the relativistic impulse approximation. By taking into consideration the effect of the relative motion of the nucleons in the nucleus, the differential scattering cross section under an angle of 0° was determined within the 190 to 430-MeV range. It was found that the maximum of the cross section shifts toward the left and the cross section values decrease throughout the whole investigated range. (TTT)

**18130** SUM RULES IN HIGH-ENERGY ELECTRON–PROTON SCATTERING. Oseguera-Valladares, Urbano. Boston; Boston Univ. (1969). 68p.

Thesis.

The nonrelativistic quark model is used, in the framework of ordinary quantum mechanics, to obtain an explicit form of the baryon current operator $J_\mu(x)$. The quark model was used to obtain explicit expressions for the electric and magnetic form factors of the proton in terms of those of the quarks. These expressions are used in the matrix element and the operator form of $J_\mu(x)$ is extracted from the resulting expression. All calculations are carried out in an infinite momentum frame. Inelastic scattering of electrons by protons is determined by a tensor $W_{\mu\nu}$ which depends on two inelastic form factors $W_1$ and $W_2$. The tensor $W_{\mu\nu}$ can also be used to determine the photoproduction cross section, and a relation between $W_2$ and the photoproduction cross section can be obtained. The tensor $W_{\mu\nu}$ depends, on the baryon current $J_\mu(x)$. The inelastic form factor $W_2(q^2,\nu)$ can be separated from $W_{\mu\nu}$ and thus a sum rule for $W_2$ is obtained in terms of the baryon current. In the infinite momentum frame, the expression for $J_\mu(x)$ is used in the sum rule. The sum rule can thus be evaluated numerically. Finally the relation of $W_2$ to the photoproduction cross section is used to compare the results with experiment. The results obtained are in reasonable agreement with experimental data. (TSS) (Diss. Abstr.)

**18131** HYPOTHESIS OF LIMITING FRAGMENTATION IN HIGH-ENERGY COLLISIONS. Benecke, J.; Chou, T. T.; Yang, C. N.; Yen, E. (State Univ. of New York, Stony Brook). Phys. Rev.; 188: 2159-69(25 Dec 1969).

An hypothesis of limiting fragmentation of the target and of the projectile in a high-energy lepton-hadron or hadron-hadron collision is defined. Arguments are given for the hypothesis. Comparisons with various models and concepts are made. Further speculations are made, including the absence of pionization processes in high-energy collisions and the dependence of multiplicity on the momentum transfer. Experiments are suggested. (auth)

**18132** EIKONAL MODEL FOR CURRENT–NUCLEON SCATTERING: ELECTRON–PROTON DEEP-INELASTIC SCATTERING. Griffith, Richard W. (Argonne National Lab., Ill.). Phys. Rev.; 188: 2112-16(25 Dec 1969).

A high-energy, small-angle diffraction model in the eikonal approximation is adapted to current-nucleon scattering. Within the framework of certain assumptions, both the longitudinal and transverse electroproduction cross sections fall off as $1/|q^2|$ for high-energy $\nu$ and large momentum transfer $|q^2|$, with the ratio $\omega = |q^2|/\nu$ fixed in the asymptotic region. Furthermore, expressions are given for the functional dependence on $\omega$ of the electroproduction structure functions $W_1$ and $W_2(\nu, q^2)$. (auth)

**18133** PROBLEM OF NEUTRON–PROTON MASS DIFFERENCE. Chanda, Rajat (Univ. of Maryland, College Park). Phys. Rev.; 188: 1988-93(25 Dec 1969).

The problem of the n-p mass difference is carefully analyzed in the framework of dispersion theory. The models recently used to obtain interesting properties of the electroproduction structure functions were studied, in order to calculate an important piece of the mass shift coming from the subtraction constant that enters into the dispersion relation for the spin-nonflip forward Compton amplitude of the nucleon. It was hoped that in some simple model this piece might be enhanced in the right direction and thereby at least the required sign reversal could be obtained. It is shown that this is not so. Thus, unless the contributions of the higher resonance states (in addition to the nucleon pole) or those of the fixed poles to the Compton amplitude are important, the n-p mass shift cannot be understood from the viewpoint of dispersion theory. (auth)

**18134** MULTIPHOTON EXCHANGE AMPLITUDES AT INFINITE ENERGY. Chang, Shau-jin; Ma, Shang-keng (Inst. for Advanced Study, Princeton, N. J.). Phys. Rev.; 188: 2385-2404(25 Dec 1969).

The summation of multiphoton exchange diagrams for ee, $\gamma e$, and $\gamma\gamma$ elastic scattering amplitudes at the high-energy limit is illustrated in detail using the infinite-momentum technique reported earlier. These diagrams are shown to give rise to amplitudes proportional to s, the center-of-mass energy squared, multiplied by simple combinations of the eikonal forms of high-energy scattering. (auth)

**18135** ASYMPTOTIC SYMMETRY AND $\omega$, $\phi \rightarrow 2\pi$ DECAYS. Mathur, V. S.; Okubo, S. (Univ. of Rochester, N. Y.). Phys. Rev.; 188: 2435-42(25 Dec 1969).

On the basis of asymptotic symmetry, the electromagnetic mixing among $\rho_0$, $\omega$, and $\phi$ was investigated. As an application, $\omega \rightarrow 2\pi$ and $\phi \rightarrow 2\pi$ decay rates were computed. (auth)

**18136** $\rho-\omega$ INTERFERENCE AND THE $\omega-\phi$ MIXING ANGLE. Parsons, Ronald G. (Univ. of Texas, Austin). Phys. Rev.; 188: 2277-80(25 Dec 1969).

The $\omega-\phi$ mixing angle of SU(3) is usually assumed to be positive, but only its magnitude is actually determined by various models of SU(3) breaking. The effect of this ambiguity of the relative sign of the SU(3) prediction of the $\gamma-\rho$ and $\gamma-\omega$ coupling constants on $\rho-\omega$ interference is investigated. The interference can be "constructive" or "destructive." In photoproduction of lepton pairs, destructive interference causes the effect of $\rho-\omega$ interference to be smaller than that of previous calculations. Two new models of $\rho-\omega$ interference in the colliding-beam reaction $e^+ + e^- \rightarrow \pi^+ + \pi^-$ are discussed. A measurement of the cross section for the latter reaction would make possible a determination of the sign of the $\omega-\phi$ mixing angle. (auth)

**18137** VECTOR-MESON DOMINANCE AND PION PRODUCTION. Schmidt, W. (Cornell Univ., Ithaca, N. Y.). Phys. Rev.; 188: 2458-64(25 Dec 1969).

On the basis of current-field-identity relation, a unified treatment and quantitatively successful calculation of pion production by $\rho$ mesons and photons is presented. The model, which is independent of free parameters, explains the empirically established facts about strong mass dependences in the $\rho$ density matrix elements (in particular, also in the combination $\rho_{11} + \rho_{1-1}$) considered as a function of the mass $k^2$ of the $\rho$ meson. These facts have been the basis for a recent criticism of the vector-meson-dominance hypothesis in pion production. But the results indicate that the current-field-identity relation is not in conflict with experiment. It is emphasized that no model-independent formulation of vector-meson dominance is possible in pion production, according to our present knowledge. (auth)

**18138** ELECTROMAGNETIC SELF-ENERGY. Wick, G. C. (Columbia Univ., New York). pp 763-70 of Theory and Phenomenology in Particle Physics. Part B. /Zichichi, A. (ed.). New York; Academic Press Inc. (1969).

An introduction is given to the electromagnetic self-energy of particles. The phenomenological evaluation of the standard expression for the electromagnetic self-mass of a particle, and the expression for the forward Compton scattering amplitude for the same photon as a Fourier transform of the time-ordered product of two Heisenberg operators are considered. (J.F.P.)

**18139** INFLUENCE OF ELECTRIC AND MAGNETIC MULTIPOLE NUCLEAR MOMENTS ON THE PHOTOPRODUCTION OF ELECTRON-POSITRON PAIRS. Kerimov, B. K.; Gavkhari, A. El. Izv. Akad. Nauk SSSR, Ser. Fiz., 33: 1360-6(Aug. 1969). (In Russian).

With the Born approximation a study is carried out on the process of forming electron-positron or muon pairs by nonpolarized gamma quanta in the field of a nucleus having electric quadrupole Q, magnetic dipole $\mu$, and octupole O moments. The resulting formulas for the cross-sections generalize the well-known Bethe–Heitler formulas for pair photoproduction in the case where the electric and magnetic multipole momenta of the nuclear target are taken into account. It is shown that at high energies and at high angles of pair particle emission, the contributions to the cross-section occurring because of the magnetic moments of the nucleus, increase substantially. At a positron emission angle $\theta = 180°$ and a high gamma energy (E > 200 MeV), the contribution to the cross-section from the magnetic photoproduction of pairs is substantial at the high-energy end of the positron spectrum. The contribution from octupole photoformation is significantly greater than the contribution from magnetic dipole photoformation. Numerical results are presented for the $^{11}B$ nucleus. (TTT)

**18140** PHOTON CROSS SECTIONS AND VECTOR DOMINANCE. von Bochmann, G.; Margolis, B.; Tang, C. L. (McGill Univ., Montreal). Phys. Rev. Lett.; 24: 483-7(2 Mar 1970).

Incoherent photoproduction of $\rho^0$ mesons, total photon-nucleus cross sections, and incoherent photoproduction of positive pions are calculated within the framework of simple vector dominance. Comparison is made with experiment. (auth)

**18141** KAON AND PION CHARGE RADII AND THE MAGNETIC MOMENTS OF rho AND K* FROM SIDEWISE DISPERSION RELATIONS. Tan, Tat Shong. Brooklyn; Polytechnic Inst. of Brooklyn (1969). 106p.

Thesis.

The charge radius of the charged kaon is calculated from the sidewise dispersion relation. The absorptive part in this approach is related to the K-$\pi$ interaction amplitudes. The intermediate states are approximated by two particle states of vector mesons and scalar mesons. In this way the absorptive part for the kaon-photon vertex is related to the VPP vertices and the photoproduction of vector mesons from two scalar mesons. Using SU(3) theory, which predicts an equal magnetic moment for charged vector mesons and zero for the neutral ones, the magnetic moment is determined for the charged vector mesons to be about $3\ e/2m\rho$. In this way the charged radius for charged kaon is determined to be about 0.1 f. A similar study of the cases for the pion and for the neutral kaon supports the above prediction of the magnetic moment for the charged vector mesons and the radius of charged pion is, in this approach, also about 0.1 f. Motivated by the important role the vector mesons play in nucleon charge structure, a model of a composed system of a nonstrange vector meson in the out periphery of the nucleon and a core for a real nucleon is constructed to test the magnetic moment of the $\rho$ meson predicted above. The probability of finding the vector meson in the outer periphery to be charged can be determined by SU(3) theory. The parity of the core may be either positive or negative. From this model with positive parity core, the anomalous moments of nucleons are found to be about 60% of the experimental results, using the vector meson magnetic moment predicted above. On the other hand this model with negative parity core predicts the anomalous moments of nucleons to be in agreement with experimental results to about 5% if the predicted vector meson magnetic moment is used. In both cases the prediction of the vector meson magnetic moment is compatible with the model. (Diss. Abstr.)

**18142** INCOHERENT PHOTON SCATTERING FROM BOUND ELECTRONS. Henry, Eugene Michael. Boulder, Colo.; Univ. of Colorado (1969). 180p.

Thesis.

In second-order perturbation theory the amplitude for transi-

tion between two stationary states of a system involves a summation over a complete set of intermediate states of the system. The intermediate states are plane waves for the case of photon scattering from a free electron, and the summation can be performed in closed form. For a bound hydrogenic electron an exact calculation of the transition amplitude must include the effects of the Coulomb field in the intermediate states. The intermediate state summation is performed by means of a relativistic Green's function which retains the full effects of the Coulomb field on the transition amplitude. The Green's function is expressed in terms of the known regular and irregular solutions to Whittaker's equation, and is then incorporated into the transition amplitude for K-shell scattering, assuming that a Dirac hydrogenic wavefunction can be used for the initial electron state. Angular integration reduces the transition amplitude to a double radial integral. A computer program was developed for evaluation of the radial integral for either bound or continuum final electron states. The resulting expressions for the transition probabilities are applied to two incoherent scattering phenomena, Compton scattering and Raman–Smekal scattering. The results show that binding effects in the intermediate electron states significantly decrease the incoherent scattering function for low momentum transfers from the values predicted by theories which assume free intermediate states. It can be concluded from this research that intermediate state binding should not be neglected in photon-electron scattering calculations. (Diss. Abstr.)

**18143** GAUGE INVARIANCE AND THE BORN APPROXIMATION IN PION ELECTROPRODUCTION. Berends, F. A.; West, Geoffrey B. (Harvard Univ., Cambridge, Mass.). Contract AT(30-1)-2076. Phys. Rev.; 188: 2538-40(25 Dec 1969).

It is shown that use of the Ward–Takahashi identity for the electromagnetic vertices of the hadrons gives a more satisfactory argument than the traditional one for the addition of subtraction terms to the Born approximation of pion electroproduction. (auth)

**18144** UNIFIED TREATMENT OF HADRONIC PROCESSES INVOLVING HIGH-MASS VIRTUAL PHOTONS. Harte, John (Stanford Linear Accelerator Center, Calif. Yale Univ., New Haven). Phys. Rev.; 188: 2372-7(25 Dec 1969).

A unified treatment of the three processes (I) lepton + proton → lepton + hadrons, (II) proton + proton → lepton pair + hadrons, and (III) lepton pair → hadrons is presented. Our dynamical model is an off mass shell bootstrap theory of the hadrons. It is shown that the model predicts slow $q^2$ (photon mass squared) variation of the differential cross sections for processes I and II in spite of the fact that the model requires the elastic and quasi-elastic hadronic form factors to decrease faster than any power in $q^2$. The cross section for process III, however, is predicted to decrease rapidly in $q^2$ and to violate the scaling law observed for process I. More detailed predictions of multiplicities and angular distributions of the final states are made, as well as the surprising predictions that for large $q^2$, the ratio $(d\sigma/dq^2)(pp \rightarrow pp + \text{lepton pair})/(d\sigma/dq^2)(pp \rightarrow pp\pi + \text{lepton pair})$ for process II and the ratio $\sigma$ (lepton pair → pp)/$\sigma$ (lepton pair → $\pi^0$ + real photon) for process III should both approach zero. The latter ratio should be comparable to 1 for $q^2 \approx 6$ BeV$^2$. (auth)

## Weak

*Refer also to abstracts 18247, 18252, 18254, and 18289.*

**18145** DIFFRACTION MODEL OF HIGH-ENERGY LEPTONIC INTERACTIONS. Piketty, C. A.; Stodolsky, L. (Laboratoire de Physique Theorique et Hautes Energies, Orsay, France). Nucl. Phys.; B15: 571-600(1970).

The cross sections for leptonic production of $\pi$, $\rho$ and $A_1$ mesons and total leptonic cross sections are estimated using the meson-dominance assumptions. The comparison of the predictions with data on deep electroproduction total cross sections provides a partial check of the ideas of the model. Simple experimental implications of the model are given. In addition, independently of the model, it is shown that the experimental test of the PCAC hypothesis in neutrino scattering at small leptonic momentum transfer does not require a cut-off on the scattering angle, but only in the momentum transfer. (auth)

**18146** VANISHING OF P(Σ⁻) ON THE BASIS OF A SIMILARITY BETWEEN THE SYMMETRY BREAKING AND NONLEPTONIC INTERACTIONS. Furui, S.; Trofimenkoff, N. N. (Australian National Univ., Canberra). Progr. Theor. Phys. (Kyoto); 42: 1485-7 (Dec. 1969).

It is shown that the property $P(\Sigma^-) = 0$ can be understood on the basis of a similarity between the octet-type SU(3) symmetry breaking of the baryon-meson pseudoscalar coupling constants and the $\lambda_4$-type nonleptonic interaction. (L.B.S.)

**18147** S-MATRIX FORMULATION OF $K_L$ AND $K_S$ DECAYS AND UNITARITY RELATIONS. Wolfenstein, L. (Carnegie-Mellon Univ., Pittsburgh). Phys. Rev.; 188: 2536-8(25 Dec 1969).

The unitarity relations for the decay of overlapping resonances as obtained by an S-matrix approach and the usual Wigner–Weisskopf approach are compared. (auth)

## Strong (General)

*Refer also to abstracts 18101, 18131, 18175, 18196, and 18197.*

**18148** (CALT-68-242) NON SHRINKING DIFFRACTION PEAKS. Zachariasen, F. (California Inst. of Tech., Pasadena. Dept. of Physics. Utah Univ., Salt Lake City. Dept. of Physics). [1969]. 17p. (CONF-700107-1). Dep. CFSTI.

From Conference on Fundamental Interactions at High Energy, Coral Gables, Fla.

The possibility is discussed that forward peaks in high-energy elastic scattering do not shrink with energy. It is assumed that in the limit $s \rightarrow \infty$, t is fixed, and an elastic differential cross section has the form $d\sigma/dt \rightarrow |f(t)|^2/16\pi$ independent of s. It is also assumed that total cross sections approach constants asymptotically. Analyticity, crossing, and unitarity are discussed. (J.F.P.)

**18149** (CERN-69-29, pp 1-30) RECENT TOPICS ON HADRON COLLISIONS. Hong-Mo, Chan (European Organization for Nuclear Research, Geneva (Switzerland)).

Recent theory underlying hadron interactions with hadrons is presented at a general level. Finite-energy sum rules, duality, and the Veneziano model are considered. (J.F.P.)

**18150** (CONF-690330–, pp 130-51) DUALITY AND HIGH-ENERGY PHENOMENOLOGY. Sonderegger, P. (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). (In French).

It is shown that the idea of duality is a powerful and simple instrument for understanding the high-energy interactions. It leads to a radical simplification of the parametrization of two-body reactions, which qualitatively account for all the observed properties. Exchange degeneracy, mechanism of zeros and the quark model, a dualistic parametrization of the KN, $\pi$N, and NN amplitudes, dualistic parametrization for experiments, and Regge cuts are discussed. (J.F.P.)

**18151** (CONF-690330-, pp 166-80) REGGE POLES WITH ABSORPTION. $\pi$N, KN, NN SCATTERING AT HIGH ENERGY. Navelet, H. (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). (In French).

The absorption and Regge pole models are discussed with a brief survey of their successes and defects. Application is made to the reactions $\pi$ + p, K + N, and N + N. (J.F.P.)

**18152** (IC-70/1) S-MATRIX FOR GAUGE-INVARIANT FIELDS. Fradkin, E. S.; Tyutin, I. V. (International Centre for Theoretical Physics, Trieste (Italy)). Jan 1970. 51p. Dep. CFSTI (U. S. Sales Only).

A method was suggested (and applied to the Yang-Mills field and to the gravitational field) for constructing the generating functional (S-matrix) for fields possessing an invariance group. The unitary and gauge-independence of the S-matrix on the mass shell is seen explicitly. (auth)

**18153** (ITF-69-90) ON THE ROLE OF $\rho$- AND $\sigma$-MESONS IN STRONG INTERACTIONS. Lendel, V. I.; Marina, D. M. (Akademiya Nauk Ukrainskoi SSR, Kiev. Institut Teoreticheskoi Fiziki). 1969. 18p. (CONF-691035-5). Dep. CFSTI (U. S. Sales Only).

From Conference on High Energy Physics and Theory of Elementary Particles, Kiev, USSR.

The universal formulas for the contribution of $\rho$- and $\sigma$-mesons in different strong interaction processes are obtained. It is shown that within a certain accuracy a selfconsistent description of the strong interaction processes of elementary particles can be obtained by means of these formulas. (auth)

**18154** QUARK SCATTERING IN RELATION TO THE BOOTSTRAP METHOD. Hunt, John Henry. Tucson, Ariz.; Univ. of Arizona (1969). 193p.

Thesis.

A "reciprocal" bootstrap is attempted between an assumed two-quark bound state and the pseudoscalar meson octet. That is, the forces binding the two-quark system are assumed to be due to the exchange of pseudoscalar mesons, while the forces binding the pseudoscalar mesons (in the quark-antiquark channels) are assumed to be due to the exchange of pseudoscalar mesons and to

the exchange of assumed two-quark bound state. The N/D method in the determinantal approximation is used to obtain two bootstrap equations in each channel. One equation in each channel comes from the requirement that D = 0 at the pole (bound-state) position. In each channel a once-subtracted dispersion relation for D is used. The requirement that (in the determinantal approximation) the pole position not be affected by small changes in the choice of subtraction constants serves to determine a second bootstrap equation in each channel. The resulting set of six equations (two in each channel) depends on eight parameters, one of which is the quark mass m. By fixing two of the parameters from physical considerations, the equations may be solved to determine the others. Values of the quark mass $m \geq 10^4$ GeV were required to satisfy these equations. This result is inconsistent with the approximations used in obtaining these equations. Hence the assumed two-quark bound state cannot be bootstrapped by exchanging pseudoscalar mesons. This result is reasonable since the quark model predicts only three-quark bound states. (Diss. Abstr.)

**18155** MULTIPERIPHERAL DYNAMICS AT GENERAL MOMENTUM TRANSFER. Ciafaloni, Marcello; DeTar, Carleton; Misheloff, Michael N. (Univ. of California, Berkeley). Phys. Rev.; 188: 2522-33(25 Dec 1969).

The group-theoretical analysis of the multiperipheral integral equation of Chew, Goldberger, and Low is extended to general momentum transfers. Using a set of variables for the multiparticle phase space analogous to those of Bali, Chew, and Pignotti, a partial diagonalization of the equation is obtained through the O(2,1) symmetry without requiring asymptotic approximations to the phase space. As an example, the technique is applied to a multi-Regge model and an Amati-Fubini-Stanghellini-type model. (auth)

**18156** COMMENTS ON BRONZAN'S TWO-MESON SOLUTION OF THE CHARGED SCALAR STATIC MODEL. North, Gerald R. (Univ. of Missouri, St. Louis). Phys. Rev.; 188: 2541-2 (25 Dec 1969).

A discrepancy is found between the two-meson solution of charged scalar theory given by Bronzan and the isobar spectrum known from strong-coupling theory. The discrepancy is traced to a failure of production amplitudes to satisfy crossing symmetry. (auth)

**18157** VECTOR CURRENTS AND CURRENT ALGEBRA. I. DUALITY AND ZERO-WIDTH MODELS. Brower, Richard C.; Weis, J. H. (Univ. of California, Berkeley). Phys. Rev.; 188: 2486-94(25 Dec 1969).

An investigation is made of the properties of vector currents consistent with the hadron bootstrap, assuming duality and zero resonance widths. First, on general grounds and independently of current algebra, it is shown that two-current amplitudes must have fixed singularities in the angular momentum plane. Then some general consequences for current amplitudes of duality and the zero-width approximation are discussed. Throughout amplitudes for one or two vector currents and an arbitrary number N of spinless hadrons are treated. (auth)

**18158** REGGE POLES IN HIGH-ENERGY SCATTERING. Lubatti, H. J. (Ecole Normale Superieure, Orsay, France. Massachusetts Inst. of Tech., Cambridge). pp 319-71 of Theory and Phenomenology in Particle Physics. Part B. /Zichichi, A. (ed.). New York; Academic Press Inc. (1969).

Some recent results from high-energy hadron–hadron interactions and relevance of the Regge pole model to these data are reviewed. An attempt is made to convey intuitively the basic predictions of the model. Some experiments for testing the predictions are considered, namely, cases in which only one trajectory is involved in the crossed channel. Complications of the model are reviewed, and elastic scattering and some quasi two-body interactions are discussed. (J.F.P.)

**18159** KRONECKER-$\delta$ TERMS IN THE PERIPHERAL MODEL AND DISPERSION RELATIONS. Rush, J. Edwin Jr. (Univ. of Alabama, Huntsville). Phys. Rev.; 188: 2535(25 Dec 1969).

It is pointed out that Kronecker-$\delta$ terms do not arise if one calculates peripheral-model contributions from unsubtracted dispersion relations. (auth)

## *Strong (Baryon No. = 0)*

*Refer also to abstracts 18156, 18224, 18294, and 18296.*

**18160** (CONF-690330-, pp 226-36) UNITARITY, ANALYTICITY, AND CROSSING SYMMETRY FOR $\pi + \pi \rightarrow \pi + \pi$ SCATTERING. Martin, A. (European Organization for Nuclear Research, Geneva (Switzerland)). · (In French).

The discussion of unitarity, analyticity, and crossing symmetry for $\pi + \pi \rightarrow \pi + \pi$ covers analyticity in one and two variables, construction of a unitary amplitude, crossing symmetry, and the Mendelstam representation. Also crossing relations for partial-wave development of the amplitude of $\pi^0 + \pi^0 \rightarrow \pi^0 + \pi^0$ interactions are studied. (J.F.P.)

**18161** CHIRAL METRIC MESON LAGRANGIANS. Barnes, K. J.; Isham, C. J. (Imperial Coll. of Science and Tech., London). Nucl. Phys.; B15: 333-49(1970).

The currents associated with the chiral-invariant pseudoscalar meson Lagrangian, constructed from a certain metric tensor on a G-manifold, are investigated. The relation between these currents, the Sugawara model and the linearized version of chiral theories in which a set of free fields is constrained, is demonstrated. The techniques are then extended to include octets of vector and axial-vector mesons. (auth)

**18162** HARD-KAON AND -PION CALCULATIONS OF THE DECAYS $K_A \rightarrow K\rho$ AND $K_A \rightarrow K^*\pi$. Srivastava, Prem P. (Centro Brasileiro de Pesquisas Fisicas, Rio de Janeiro). Nucl. Phys.; B15: 461-76(1970).

The strong decays $K_A \rightarrow K\rho, K^*\pi$ are discussed in a current algebra approach by writing unsubtracted dispersion relations for the matrix elements of appropriate retarded commutators of currents or current divergences between single-particle states and vacuum, at (arbitrary) fixed linear combination of the two momentum transfers. This allows the pole contributions from both the variables to be retained. Moreover, the various form factors appearing in the calculation are allowed to satisfy at most once-subtracted dispersion relations and are treated on equal footing. The current algebra method is used to set up sum rules among the coupling constants and the subtraction constants without using the hypothesis of partial conservation of axial current. Their solution allows the partial-decay widths to be calculated and the Weinberg sum rules to be rederived as self consistency conditions. (auth)

**18163** CHIRAL SU(3) x SU(3) THEOREMS FOR PSEUDOSCALAR–PSEUDOSCALAR SCATTERING AMPLITUDES. Osborn, Hugh (Queen Mary Coll., London). Nucl. Phys.; B15: 501-24(1970).

The set of all soft-meson theorems for all scattering amplitudes of the pseudoscalar octet, with two particles off shell, employing PCAC for each pseudoscalar state, current algebra and the $\sigma$-terms following from $(3,\bar{3}) + (\bar{3},3)$ breaking of chiral SU(3) × SU(3) symmetry are given. The approximation to the scattering amplitude in the low-energy region by a linear expansion in the invariants is uniquely determined by the absence of exotic $\sigma$ terms for $\pi\pi$ (as was first shown by Weinberg), $\pi K$, and KK scattering, when the $F_\pi = F_K$ is also required for consistency. To derive the linear expansions for amplitudes involving the $\eta$, $(3,\bar{3}) + (\bar{3},3)$ breaking is used in an essential manner; then the value of the symmetry breaking parameter c given by Gell-Mann, Oakes and Renner, the coupling of scalar densities to pseudoscalar states and the usual octet mass formula are naturally recovered. The application of the Adler consistency condition to the Veneziano formulas for pseudoscalar scattering, and its connection with chiral symmetry, are discussed. It is shown that the Adler condition can be justified only when there are exotic channels present. (auth)

**18164** CALCULATION OF $A_1$ AND B-MESON DECAYS USING SUM RULES AND THE VENEZIANO MODEL. Pancheri-Srivastava, Giulia (Northeastern Univ., Boston). Nucl. Phys.; B15: 525-39(1970).

The decay rates of $A_1$ into $\rho\pi$ and B into $\omega\pi$ are calculated from a study of the process $\pi A_1 \rightarrow \pi\omega$. The rates are obtained using finite energy dispersion relations (FEDR) as well as the Veneziano model. The results of the Veneziano model agree with those from FEDR under a certain hypothesis on the $\rho$-trajectory slope. Under this hypothesis the Veneziano model predicts for the anomalous magnetic moment of $A_1$ and the value $\lambda_A = 0$, which is consistent with current algebra. The angular distribution for the decay $B \rightarrow \pi\omega$ is obtained in agreement with a phenomenological analysis. (auth)

**18165** APPLICATIONS OF THE EMBEDDING OF NON-LINEAR MESON TRANSFORMATIONS IN A EUCLIDEAN SPACE. Isham, C. J. (Imperial Coll. of Science and Tech., London). Nucl. Phys.; B15: 540-8(1970).

The embedding of the nonlinear pseudoscalar chiral realization space into the Euclidean space R(18) is used to clarify the connection between the linear and non-linear chiral theories and to construct symmetry-breaking terms. This connection is then extended to include octets of gauge particles. (auth)

**18166** VENEZIANO MODEL AND INTERNAL STRUCTURE OF HADRONS. Tanaka, Sho (Kyoto Univ.). Progr. Theor. Phys. (Kyoto); 42: 1483-5(Dec 1969).

An attempt is made to interpret the Veneziano amplitude as a consequence of a propagation of an extended particle and further to study the internal structure of this extended particle. The amplitude for $\pi\pi$ scattering is considered. (L.B.S.)

**18167** TOTAL CROSS SECTION IN THE DUAL SYMMETRIC THEORY OF HADRONS. Frye, G. (Yeshiva Univ., New York). Phys. Lett.; 31B: 26-9(5 Jan 1970).

The Freund-Harari principle of diffractive duality is implemented by summing the square of a t−u Veneziano tree-graph amplitude for the production of two resonances over all two body final states. This theory provides the basis for an ab initio calculation of the total cross section of the dual symmetric "rubber band" model and shows that the large degeneracy of daughter states leads (potentially) to a constant total cross section. (auth)

**18168** ANALYSIS OF MESON PRODUCTION UTILIZING A CHIRAL SU(3) x SU(3) PHENOMENOLOGICAL LAGRANGIAN. Turner, Leaf. Madison, Wis.; Univ. of Wisconsin (1969). 130p. Thesis.

Extending the Weinberg covariant derivative technique, for the study of multiple soft meson processes, a chiral SU(3) ⊕ SU(3) phenomenological Lagrangian is derived with which meson-meson scattering, meson-baryon scattering, and single meson production (PB → PPB) are analyzed. The vector and axial vector currents satisfy the Gell−Mann current algebra hypothesis. A chiral symmetry-breaking term, which would be absent in the limit of zero meson mass, appears in the Lagrangian to guarantee partial conservation of the axial vector current (PCAC). The vector current is strictly conserved. Only three diagram contributions are utilized in calculating amplitudes. It is discovered that the only ambiguity in the physical meson-meson scattering amplitudes, appearing as the parameter $\xi$, is also the only one present in the single meson production amplitudes. This uncertainty is shown to be related directly to the arbitrariness of the chiral symmetry-breaking mechanism. It is not yet feasible to resolve the ambiguity by means of meson-meson scattering experiments. Instead, the available single meson production data near threshold must be utilized. The best such existing data are for $\pi N \to \pi\pi N$. The resolution of the ambiguity by use of the $\pi N \to \pi\pi N$ data strongly supports Weinberg's analysis of $\pi$-$\pi$ scattering. These results are used to derive other single meson production cross sections, which are then compared with the data. The results for meson-baryon and meson-meson scattering processes are also discussed in detail. Double pion production ($\pi N \to \pi\pi\pi N$) is also treated. (Diss. Abstr.)

**18169** REGGE TRAJECTORY OF THE PION USING O(4) GROUP THEORETIC FORMALISM. Lipinski, Hubert Maria. San Diego, Calif.; Univ. of California (1969). 82p. Thesis.

In the context of the Bethe−Salpeter equation, the properties of the O(4) expansion of the $\pi p$ scattering amplitude are studied. It is found that the expansion has the required kinematical singularities. Assuming the Regge trajectory of the pion has M = 1 at t = 0, the form of the $\pi\pi p$ vertex functions is found for two trajectory mixing models. It is also shown that our expansion satisfies Carlson's theorem. In order to test the M = 1 hypothesis for the pion, the O(4) projected $N\bar{N}$ Bethe−Salpeter equation is solved for the pion's Regge trajectory in the region near t = 0. It is found that there are two Regge trajectories with the same quantum numbers as the pion which lie above J = −1. At t = 0, the highest lying trajectory has Toller quantum number M = 1. The other Regge trajectory lies somewhat further below and has the Toller quantum number M = 0. In addition to the intercepts, the slopes of these trajectories are also calculated. (Diss. Abstr.)

**18170** NUCLEON–ANTINUCLEON VECTOR BOUND STATES. Patergnani, G. (Univ., Padua). Z. Phys.; 232: 223-30(1970).

A system of nucleon-antinucleon with the quantum numbers of various existing scalar and pseudoscalar particles was previously studied with a Bethe−Salpeter equation in the ladder approximation. That analysis is now extended to vector particles, that is to bound states with the quantum numbers of the $\omega$, $\rho$, $\phi$. The interaction is produced by $\pi$ mesons, plus a phenomenological vector interaction. The conclusions for scalar and pseudoscalar particles are confirmed also for the vector states: that is to obtain the experimental value for the coupling constant $g_{N\bar{N}\pi}$ the used model requires for cut off values between 1 to 4 nucleonic masses; the effect of the vector interaction is always attractive. (auth)

**18171** SIMPLE MODEL FOR LOW-ENERGY PION–PION SCATTERING. Graham, R. H.; Johnson, R. C. (Univ. of Toronto). Phys. Rev.; 188: 2362-6(25 Dec 1969).

A simple model for low-energy pion-pion scattering is given, which expresses the S-wave phase shifts in terms of the $\rho$-meson parameters. A vital assumption is that the isospin amplitudes are as free as possible from singularities—that is, that the threshold branch points are weak, and can be treated by successive approximation. The present version of the model obeys elastic unitarity above threshold. If a parameter is chosen in a range such that the amplitudes are crossing-symmetric below threshold to a high degree of accuracy, and such that the $\pi^0\pi^0$ S-wave amplitude obeys a set of constraints proven from axiomatic field theory, then the numerical predictions agree reasonably with experiment. A method of improving the model using partial-wave dispersion relations is indicated. Comparison with other, more complicated, models suggests that these often contain many superfluous features which obscure the essential origins of their predictions. It is concluded, for example, that there is no real difference between duality and interference models, as far as prediction of S-wave $\pi$-$\pi$ scattering lengths are concerned. (auth)

**18172** ALGEBRAIC STRUCTURE OF CURRENT ALGEBRA, SUPERCONVERGENCE SUM RULES, AND THE INFINITE-MOMENTUM METHOD. Shei, Sun-sheng (Harvard Univ., Cambridge, Mass.). Phys. Rev.; 188: 2274-80(25 Dec 1969).

A derivation of Weinberg's formulas is presented for the algebraic structure of current algebra and superconvergence sum rules in the case of massive pions, using the infinite-momentum method. It is shown that Weinberg's formulas are closely related to the fact that there is no T = 2 part in some double commutation relations between axial charges $Q_5^a$, $Q_5^b$ and the generators of inhomogeneous Lorentz transformations. (auth)

**18173** CROSSING-SYMMETRIC AMPLITUDES WITH ARBITRARY REGGE BEHAVIOR BASED ON ELEMENTARY SYMMETRIC FUNCTIONS. Thiebaux, M. L. (Univ. of Massachusetts, Amherst). Phys. Rev.; 188: 2283-6(25 Dec 1969).

A sequence of amplitudes for $\pi\pi \to \pi\omega$ is constructed exhibiting exact crossing symmetry, Regge asymptotic behavior, direct-channel poles, and arbitrary nonlinear trajectories. The sequence, constructed out of the elementary symmetric functions of s, t, and u, possesses some of the desired features in a limiting sense only. In the complex angular momentum plane, any member of the sequence contains a leading finite array of simple poles spaced by two units, and additional nonleading arrays of higher-order singularities. A similar amplitude for the elastic scattering of neutral scalar bosons is proposed to test the unitarizability of the representation by finding a suitable nonlinear trajectory. (auth)

**18174** U(3) CURRENT ALGEBRA AND SPECTRAL SUM RULES FOR VECTOR MESONS. Wienke, B. R.; Deshpande, B. R. (Northwestern Univ., Evanston, Ill.). Phys. Rev.; 188: 2117-20 (25 Dec 1969).

A U(3) current algebra is postulated and Weinberg's first rule is extended to this group. The symmetry-breaking mechanisms of Oakes and Sakurai and of Das, Mathur, and Okubo are also extended to U(3). In the Das, Mathur, and Okubo extension, the results of Akiba and Kang are duplicated. In both cases, the SU(6) results which impose $\rho$-$\omega$ degeneracy and fix the current mixing angle uniquely are maintained. Experimental predictions are compared with existing data, in particular, for the leptonic decays of $\rho$, $\omega$, and $\varphi$. (auth)

**18175** DYNAMICAL REGGE TRAJECTORIES FROM THE MULTIPERIPHERAL MODEL. Ball, J. S.; Marchesini, G. (Univ. of California, Berkeley). Phys. Rev.; 188: 2508-16 (25 Dec 1969).

A multiperipheral model, based on one-pion-exchange dominance of low-momentum-transfer processes, is used to study the dynamical origin of the leading Regge trajectories which are coupled to the two-pion system. A Bethe-Salpeter technique is used to calculate the leading singularities in the angular-momentum plane from an input interaction that is determined by the observed low-energy pion-pion scattering amplitude plus the high-energy contribution of the Pomeranchon. The solution results in a partial bootstrap system in which the parameters of the Pomeranchon are determined self-consistently. The output trajectories are found to correspond to what we conjecture are effective Regge trajectories which in reality correspond to both Regge-pole and cut contributions. The trajectories and coupling constants obtained seem to be in reasonable agreement with the values allowed by experiment. (auth)

**18176** VENEZIANO MODEL AND THE ADLER−WEISBERGER SUM RULES FOR K-$\pi$ SCATTERING. Corrigan, Dennis (Univ. of California, Los Angeles). Phys. Rev.; 188: 2465-8(25 Dec 1969).

It is shown that the contributions to the Adler-Weisberger sum rule (AWSR) in the simplest Veneziano model for K-$\pi$ scattering are too large by a factor of 2. A modification of the simplest Veneziano amplitude is proposed which satisfies (i) the Adler self-consistency condition, (ii) the AWSR, and (iii) the $K^*(890)$ having the experimentally observed width of 50 MeV. If this modified Veneziano amplitude is required to satisfy the Adler−

Weisberger-type sum rule for zero-mass K mesons scattering from physical pions, the ratio $F_K/F_\pi$ is predicted to be 1.26, in good agreement with experiment. (auth)

**18177** IS THERE ANOTHER $2^+$ NONET? Fujii, Yasunori (Purdue Univ., Lafayette, Ind.). Phys. Rev.; 188: 2423-5(25 Dec 1969).

Motivated by the observed double-peaked structure of the $A_2$ meson, the simple possibility that there is another set of nonet $2^+$ mesons, which is almost degenerate to the usual ones, is exploited. A scheme is constructed in such a way that some unusual predictions could be tested with a slight increase in experimental accuracy. The Veneziano-Lovelace-type amplitudes for pseudoscalar meson scattering are also reexamined. (auth)

**18178** TWO-LEVEL FORMULA FOR MAXIMALLY OVERLAPPING RESONANCES AND ITS APPLICATION TO THE $A_2$ MESON. Fujii, Yasunori (Purdue Univ., Lafayette, Ind.); Kato, Masaaki. Phys. Rev.; 188: 2319-30(25 Dec 1969).

A two-level formula for overlapping and inelastic resonances is examined. Detailed discussions are made for the extreme case in which the partial-wave S-matrix elements have two poles and two zeros lying on the same vertical line in the complex energy plane. A dipole is also included as a special case. All the important results (some of which look rather strange) are presented in a general and transparent way without using detailed numerical calculations. A peculiar phenomenon suggested by Coulter and Shaw is naturally explained. The formalism is applied to the observed double-peaked structure of the $A_2$. An analysis of the minor decay modes $A_2 \to \pi\eta$ and $A_2 \to K\bar{K}$ suggests that the choice of two resonances, one narrow and one broad, is somewhat favored over other choices—a dipole and two equal-width resonances. (auth)

**18179** DYNAMICAL EFFECTS IN OVERLAPPING RESONANCES. Coulter, Philip W.; Shaw, Gordon L. (Univ. of California, Irvine). Phys. Rev.; 188: 2443-5(25 Dec 1969).

The dynamical effects of two overlapping resonances are examined. The experimentally observable positions and widths $s_i$, $\Gamma_i$ are related to the isolated quantities $s_i$, $\bar{\Gamma}_i$ which would occur if the resonances were widely separated. Dramatic enhancements or depressions of $\Gamma_i/\bar{\Gamma}_i$ are demonstrated. The model is applied to the double-peaked $A_2$ with the results that one of the resonances is quite narrow: $\bar{\Gamma} \lesssim 5$ MeV. Conjectures on exotic resonances are made. (auth)

**18180** BOSON RESONANCES. Kienzle, W. (CERN, Geneva). pp 373-467 of Theory and Phenomenology in Particle Physics. Part B. /Zichichi, A. (ed.). New York; Academic Press Inc. (1969).

Boson experiments are discussed, and an attempt is made to fit known boson states into a simple quark model, essentially along the lines of previous work. Also some open questions are considered, and experiments proposed. (J.F.P.)

**18181** DUAL PARTNER FOR THE POMERANCHUKON. Lyth, D. H. (Univ. of Lancaster, Eng.). Phys. Rev. Lett.; 24: 487-90(2 Mar 1970).

A new Regge singularity is postulated which together with the Pomeranchukon forms a "dual set." As a result, there is associated with the Pomeranchukon background of Harari and Freund an additional contribution which occurs, however, only in channels with the quantum numbers of the vacuum. The new singularity $\alpha_{DP}$ couples to the (exotic) I = 2 $\pi\pi$ channel and probably has $\alpha_{DP}(0) \geq 0$. It is also postulated that (other) Regge cuts form a further "dual set," and are therefore built out of backgrounds, not out of resonances; hence the generalized interference model should be valid for cut-dominated processes. (auth)

**18182** INTEGRAL CONSTRAINTS FOR PARTIAL WAVE AMPLITUDES FROM CROSSING SYMMETRY. Grassberger, P. (Univ. of Kabul, Afghanistan). Z. Phys.; 232: 374-7(1970).

By use of crossing symmetry, integral relations among partial wave amplitudes for elastic scattering of self-conjugate mesons are derived. They involve the amplitudes for unphysical values of s between the pseudothreshold $(m-\mu)^2$ and the threshold $(m+\mu)^2$. (auth)

**18183** A COMPLETE UNITARY REPRESENTATION FOR THE RESIDUE FUNCTION $\beta$ AND ASYMPTOTIC BEHAVIOR OF Im $\alpha$. Karpf, Armin D.; Liehl, Hermann J. (Univ., Freiburg i.B.). Z. Phys.; 232: 378-89(1970).

The unitary Cheng representation for partial wave amplitudes in terms of Regge-trajectories is used to derive a new unitary representation for the residue function $\beta(s)$, which allows to evaluate $\beta(s)$ for all values of s, especially for negative values. The discussion of both representations gives three different arguments that Im $\alpha(s)$ has to decrease exponentially as s increases. The new formula also allows to establish a unitary bootstrap system for $\beta(s)$ and Im $\alpha(s)$. (auth)

## Strong (Baryon No. = 1)

*Refer also to abstracts 18263 and 18296.*

**18184** (CERN-69-29, pp 31-45) CHIRAL DYNAMICS. Zumino, B. (European Organization for Nuclear Research, Geneva (Switzerland)).

The discussion of the chiral dynamics of elementary particles includes chiral transformations, the chiral Lagrangian, currents, and the $\pi^0 \to 2\gamma$ decay. (J.F.P.)

**18185** (CONF-690330–, pp 181-7) MODEL FOR PARTIAL WAVES AT HIGH ENERGY. Salin, Ph. (European Organization for Nuclear Research, Geneva (Switzerland)). (In French).

A model for partial waves in the case of high-energy elastic scattering $a + a \to a + a$ is discussed. Right and left cuts in the s plane are considered. Applications are made to $\pi + N$ scattering, photoproduction, and coupled reactions such as $\pi + N \to \pi + N$ and $\pi + N \to \eta + N$. (J.F.P.)

**18186** (CONF-690330–, pp 189-201) GENERALIZATION OF THE VENEZIANO MODEL TO MESON–BARYON SCATTERING. Storrow, J. K. (European Organization for Nuclear Research, Geneva (Switzerland)).

Previous work on the extension of the Veneziano model for $\pi + N$ and $K + N$ interactions is discussed. Crossing symmetry, Regge asymptotic behavior, and simple poles at points corresponding to resonances on Regge trajectories are considered. (J.F.P.)

**18187** (CONF-690330–, pp 202-16) A SHORT REVIEW OF RESULTS FROM CONTINUOUS MOMENT SUM RULES. Odorico, R. (Trieste Univ. (Italy). Istituto dei Fisica).

Following a brief summary of the derivation, properties, and analysis of the continuous moment sum rules, a short review is given of some phenomenological results which were obtained using these sum rules. Also the main results from continuous-moment sum rule analyses of near-forward meson ($\pi$) + N scattering and meson ($\pi$) photoproduction are discussed. (J.F.P.)

**18188** (CONF-690330–, pp 217-24) INTRODUCTION TO BACKWARD SCATTERING. Tran Thanh Van, J. (Paris Univ., Orsay (France). Laboratoire de Physique Theorique et Hautes Energies). (In French).

The discussion of backward scattering covers the invariant amplitudes, exchange particles in $\pi^+ + p \to \pi^+ + p$, $\pi^- + p \to \pi^- + p$, and $\pi^- + p \to \pi^0 + n$ interactions, Reggeization, trajectory dominance, and the interference model of $N_\alpha$ and $N_\gamma$ trajectories. (J.F.P.)

**18189** N, $\Delta$, AND $\rho$-EXCHANGE IN PION-NUCLEON SCATTERING. Engels, J. (Univ., Karlsruhe, Ger.); Hoehler, G.; Petersson, B. Nucl. Phys.; B15: 365-88(1970).

The N, $\Delta$ and $\rho$-exchange contributions to the $\pi$N charge exchange amplitude as derived from fixed-t and fixed angle $\theta = 180°$ dispersion relations are compared with the corresponding terms in a chiral Lagrangian. A new evaluation of the backward dispersion relation combined with the forward dispersion relation gives information on the physical origin and the magnitude of the corrections to the simple $\rho$-dominance and N, $\Delta$, $\rho$-exchange models. The result for the $\pi N\Delta$ coupling constant $g^{*2}/4\pi = 0.26$ differs from that of other authors and the determination of the $\rho$NN coupling constants leads to difficulties which were ignored in earlier work. The equality between the forward and backward amplitudes at threshold gives a relation between coupling constants similar to a result which was recently derived from chiral Lagrangians. (auth)

**18190** ON THE VENEZIANO FORMULATION OF PION–NUCLEON SCATTERING. Hendry, A. W.; Jones, S. T.; Wyld, H. W. Jr. (Univ. of Illinois, Urbana). Nucl. Phys.; B15: 389-96(1970).

Igi's extension of Veneziano's model to pion-nucleon charge-exchange scattering is examined. It is found that it is possible to obtain a good fit to the forward scattering data, but both forward and backward directions could not be fitted simultaneously. The uniqueness of the formulas is discussed. (auth)

**18191** CHIRAL SYMMETRY WITH THE $\rho$-PHOTON ANALOGY. Ohta, Tadayuki (Tokyo Univ.); Ebata, Takeshi. Progr. Theor. Phys. (Kyoto); 42: 1372-93(Dec 1969).

The chiral invariant Lagrangian, which is consistent with the $\rho$-photon analogy and the gauge invariance for the photon, is presented. The main purpose is to investigate the $\rho$-exchange con-

tributions to various low-energy reactions, especially $\pi N \rightarrow \pi N$, $\pi^+ p \rightarrow \pi^0 N^{*++}$ and $K^+ p \rightarrow K^0 N^{*++}$. The general property of the $\rho$-meson coupling with hadrons is obtained. (auth)

**18192** DIFFRACTION DISSOCIATION AND THE FINAL-STATE INTERACTION. Kagiyama, Shigenori; Uehara, Masayuki (Kyushu Univ., Fukuoka). Progr. Theor. Phys. (Kyoto); 42: 1476-8(Dec 1969).

The Drell-Hiida model for explaining the bump in the $\pi N$ mass spectrum at ~1.4 GeV from high-energy pp or $\pi p$ interactions is examined. The model gives this bump through the partial-wave expansion and the effect of the final state interaction. (L.B.S.)

**18193** NEW APPROACH TO HIGH ENERGY SCATTERING. Horn, D. (California Inst. of Tech., Pasadena). Phys. Lett.; 31B: 30-3(5 Jan 1970).

A possible interpretation of the Serpukhov data of total cross sections is described. The break in the trend of the data is associated with an "ionization point" for baryon resonances. Both conventional Regge expansions and Pomeranchuk's theorem are assumed to fail from there on. Implications of these ideas and their experimental tests are discussed. (auth)

**18194** MASS AND WIDTH OF $\Delta(1236)$. Taguchi, Yukio (Univ. of Osaka Prefecture, Sakai, Japan); Yamamoto, Kunio. Progr. Theor. Phys. (Kyoto); 42: 1341-8(Dec 1969).

It is pointed out that the position and the width of the peak of $\pi$-N elastic scattering in the $I = J = 3/2$ state differ from the mass and the width of $\Delta(1236)$ respectively, because of the effect of the "background scattering." By taking account of this effect the mass 1214 MeV and the width 97 MeV of $\Delta(1236)$ resonance are obtained from $\pi$-N elastic scattering data alone. These values are in good agreement with those obtained in the $\gamma + p$ and the $K^+ + p$ reactions. It can be explained why the mass and the width of $\Delta(1236)$ produced in the $\gamma + p$ and the $K^+ + p$ reactions are different from the usual values. A brief discussion is made about the relation between our theory and Jackson's theory with the energy dependent width. (auth)

**18195** ON THE AZIMUTHAL EFFECTS OF TWO-PRONG $\pi N$ AND THREE-PRONG DD EVENTS PRODUCED BY 17.2-GeV/c $\pi^-$ MESONS. Bozoki, G.; Gombosi, E.; Suranyi, G. (Central Research Inst. of Physics, Budapest). Acta Phys. Acad. Sci. Hung.; 26: 371-85(1969).

A deviation from isotropy in the azimuthal angular distribution of secondary particles of two- and three-prong pion-nucleon interactions is observed in emulsion at 17.2 GeV/c. Attempts are made using Monte Carlo calculations to interpret these azimuthal effects on the basis of the kinematics of reactions $\pi^- p \rightarrow p\pi^-(k\pi^0)$ and $\pi^- p \rightarrow n\pi^+\pi^-(k'\pi^0)$ and the diffraction dissociation of pions on nuclei. A new method is given for the selection of the contribution of DD interactions from three prong events. Using this method $\lambda_{DD} = (1065 \pm 288)$ m and $\lambda_{DD} = (113 \pm 13)$ m are obtained for the mean free path of the diffraction dissociation in emulsion at ~7 and 17.2 GeV/c, respectively. The possible influence of the Deck effect in the case of three prong events is also investigated. (auth)

**18196** RELATIVISTIC TWO-BODY THEORY. Thompson, Richard Hall. Cleveland; Case Western Reserve Univ. (1968). 159p.

Thesis.

A study of the reduction of the Bethe–Salpeter equation for scalar mesons from its customary four-dimensional, non-euclidean form to a more convenient three-dimensional equation by a method due to Blankenbecler and Sugar and an extension of this method to fermions. This reduction is carried out in a covariant manner and in such a way that the new equation satisfies the two-particle elastic unitarity condition. In the first several chapters the theory for scalar (spinless) particles is developed. Solutions are obtained to the reduced equation by matrix inversion and via the Fredholm expansion and find that the results compare quite favorably to the variational solutions to the Bethe–Salpeter equation even when the coupling constant is quite large. The method is extended to include fermions and make a direct comparison with experiment. For the low energy pi-nucleon phase shifts, the $J = T = 3/2$ phase shift is calculated in an attempt to predict the position of the resonance. It turns out that the integral equation for fermions contains an ultraviolet divergence requiring the introduction of a parameter to describe the short-range nature of the force. Hence, only a fit to the data is possible. Finally, the high energy ($p_{lab} \sim 10$ BeV/c) $\pi^+$-p differential cross section is calculated. The model is based on nucleon exchange and is, therefore, expected to apply only for large backward angles. The results of this calculation show that the model contains some of the correct features of the $\pi^+$-p system, but, quantitatively, the calculation does not agree with experiment. (TSS)(Diss. Abstr.)

**18197** DUAL MODELS WITHOUT PARITY DOUBLING. Bardakci, K.; Halpern, M. B. (Univ. of California, Berkeley). Phys. Rev. Lett.; 24: 428-31(23 Feb 1970).

The recently proposed fixed cuts are dualized. The resulting functions apparently allow construction of parity-doubling-free models for arbitrary processes. Applications are made to the reciprocal and meson bootstraps. (auth)

**18198** ANGULAR DISTRIBUTION IN ELASTIC SCATTERING OF HIGH-ENERGY HADRONS. Azimov, S. A.; Arushanov, G. G. (Inst. of Nuclear Physics, Tashkent). Doki. Akad. Nauk SSSR; 188: 53-5(1 Sep 1969). (In Russian).

The problem of the relation between the proper part of scattering amplitude and the virtual part at the region of diffraction peak was previously studied within the limits of a simplest model corresponding to a certain core in a scatterer in which scattering takes place at large angles. G. G. Arushanov (Yader. Fiz.; 9: 6 (1969)) showed that the model was suitable for qualitative description of differential cross sections of hadron scattering at high energies in the range of angles from $\leq 0\theta \leq 180°$. An attempt was made of confirming the above statement using an example of $\pi^+$p-scattering at momenta $p_e = 4$ GeV/c; $\pi^-$p scattering as $p_e = 8$ Gev/c and pp-scattering at $p_e = 21$ GeV. (R.V.J.)

**18199** IS A SUBTRACTION REALLY NECESSARY IN THE ISOSPIN EVEN $\pi N$ DISPERSION RELATION? Hoehler, G.; Strauss, R. (Univ., Karlsruhe, Ger.). Z. Phys.; 232: 205-22(1970).

It is shown that the assumption of an unsubtracted fixed-t dispersion relation for the isospin even $\pi N$ amplitude $A^+$ is compatible with all data. The prediction for the subtraction function agrees reasonably well with independent determinations. The assumption has the consequence that the ratio of the s-channel helicity flip and nonflip amplitudes vanish in the high energy limit. (auth)

**18200** TESTS FOR EIGHTFOLD-WAY OCTETS IN THE BARYON SPECTRUM. Roberts, A. P.; Box, M. (Monash Univ., Victoria, Australia). Phys. Rev. Lett.; 24: 426-8(23 Feb 1970).

A search is reported for octets among baryons of spin $\leq 5/2$, using the Gell-Mann–Okubo mass formula as a selection criterion. The likely number of unphysical "chance" octets so selected is estimated by another search using unphysical mass formulas. The findings discourage reliance on mass formulas for classification purposes, and tend somewhat against the existence of further octets. (auth)

**18201** NONRELATIVISTIC MODEL OF N-FERMION BOUND STATES. Wimmer, Peter Leslie. Miami, Fla.; Univ. of Miami (1969). 59p.

Thesis.

A nonrelativistic model of N-fermion bound states is proposed. It is concerned with the relative motion of the sub-particles, and the intrinsic spins of the fermions; dependence on center of mass and internal (I-spin, hypercharge, etc.) variables are separated out. Eigenvalue equations for total angular momentum, parity, and mass are written down, with the requirement of invariance under the Born reciprocity principle applied to the relative coordinates and momenta. Ladder operators connecting different states are derived, and are used to construct all solutions from a ground state. The solutions for 3-fermion bound states are applied to baryonic resonances, yielding mass formulas for $N^*$, $Y_3^*$, and $Y_1^*$ resonances. (Diss. Abstr.)

**18202** CALCULATION OF KN AND $\overline{K}N$ SCATTERING LENGTHS AND PHASE SHIFTS BY A POLE DOMINANCE METHOD. Sanda, Anthony Ichiro. Princeton, N. J.; Princeton Univ. (1969). 105p.

Thesis.

Recently a procedure for representing a two-particle scattering amplitude as a sum of resonances in all three channels was derived by J. H. Schwarz. In addition to satisfying crossing symmetry, such a formula has a large domain of validity in the s, t, u plane. This method is applied here to KN and $K\overline{N}$ scattering. The experimental parameters for the scattering, calculated in the low energy region, are: (1) S-wave scattering lengths for KN isospin zero and one channels. (2) $S_{01}$, $P_{01}$, $S_{11}$, $P_{13}$, and $D_{13}$ phase shifts (2) for KN isospin zero and one channels in energy region up to center-of-mass momentum 0.3 BeV/c. (3) The real part of the s-wave scattering lengths for $\overline{K}N$ isospin zero and one channels. In addition, a sum rule relating the amplitudes for the KN channel and $K\overline{N}$ channel is obtained. It is satisfied well for the real part of the amplitude and is not satisfied for the imaginary part. Due to the lack of well-established experimental values for the coupling of $\omega$, $\phi$, and the s-wave $\sigma$ resonance in the reaction $K\overline{K} \rightarrow N\overline{N}$, a parameter is introduced. With this one adjustable parameter, all s-wave scattering lengths except the real part of the $\overline{K}N$

zero-isospin scattering length are calculated and found to be consistent with experiment. For the real part of the $\bar{K}N$ zero-isospin scattering length we obtain qualitative agreement. Unfortunately, a definite conclusion on the coupling strength of the $\sigma$ in the reaction $K\bar{K} \rightarrow N\bar{N}$ cannot be drawn since the inclusion of $\sigma$ does not improve the agreement of all the calculated phase shifts with the experimental ones. The qualitative behavior of the five above-mentioned phase shifts is obtained without any additional adjustable parameters besides the $\sigma$ coupling strength. (Diss. Abstr.)

**18203** STATISTICAL-MODEL CALCULATION OF THE BRANCHING RATIOS OF N* (1470). Abramovici, A.; Vekas, L. (Univ. of Timisoara, Rumania). Acta Phys. Acad. Sci. Hung.; 26: 417-19(1969).

The branching ratios of various decay modes of N(1470) having isospin $\frac{1}{2}$ and $\frac{3}{2}$ is obtained. Calculations are carried out using a formula for the probability of a final state starting from an initial state. (J.F.P.)

**18204** EXTRAPOLATION OF ELASTIC DIFFERENTIAL $\pi p$ CROSS SECTION TO VERY HIGH ENERGIES AND THE PION FORM FACTOR. Chou, T. T.; Yang, C. N. (State Univ. of New York, Stony Brook). Contract AT(30-1)-3668B. Phys. Rev.; 188: 2469-70(25 Dec 1969).

A least-squares fit is made of elastic $\pi p$ differential cross sections and then extrapolated to infinite energies. The result is used, in the droplet model, to evaluate the pion form factor. The pion root-mean-square radius is found to be $(0.63 \pm 0.02) \times 10^{-13}$ cm, which is slightly smaller than that of the proton. (auth)

**18205** STATIC MODEL USING CROSSING-SYMMETRIC OFF-SHELL EQUATIONS SATISFYING TWO-PARTICLE UNITARITY. Freeman, David F.; North, Gerald R.; Rubin, Morton H. (Univ. of Pennsylvania, Philadelphia). Phys. Rev.; 188: 2426-34(25 Dec 1969).

Off-shell equations for the $\pi^- p$ and $\pi^+ p$ elastic scattering amplitudes are derived for a static model, based on charged scalar theory. These amplitudes satisfy elastic unitarity below the three-particle cut and are related by crossing symmetry. The equations are solved numerically in the bound-state region for the entire range of coupling, and the results compared with the known results of charged scalar theory. In particular, calculations of the bound-state $N^{++}$ are reasonable. Possible extensions to more realistic models are discussed. (auth)

**18206** DECAYS OF HIGH-SPIN OBJECTS PRODUCED BY PION EXCHANGE. Chan, L.; Williams, P. K. (Florida State Univ., Tallahassee). Phys. Rev.; 188: 2455-8(25 Dec 1969).

The OPE-$\delta$ prescription for approximating the absorptive one-pion-exchange (OPE) predictions for spin-density matrix elements was applied to quasi-two-body reactions with final-state particles of arbitrary spins. Results indicate that the model is able to give the qualitative features of usual absorptive-one-pion-exchange (OPEA) models. Agreement between OPE-$\delta$ and OPEA predictions is good in general. Predictions of the two models for diagonal density matrix elements for the reaction $\pi + N \rightarrow f^0 + N$ tend to disagree at larger angles. (auth)

**18207** PION-NUCLEON AND KAON-NUCLEON SCATTERING IN THE VENEZIANO MODEL. Berger, Edmond L.; Fox, Geoffrey C. (Univ. of California, Berkeley). Phys. Rev.; 188: 2120-54 (25 Dec 1969).

A comprehensive phenomenological examination of the Veneziano ansatz for pion-nucleon and kaon-nucleon processes is given. Using invariant amplitudes constructed as sums of beta-function terms, an attempt is made to fit simultaneously all the relevant high- and low-energy scattering data as well as the elastic widths of baryon resonances. A useful technique is discussed for ensuring that the theoretical amplitudes will possess the observed spin-parity structure of the physical spectrum of baryon states. The main conclusions are the following: (a) Sizable subsidiary terms are required. (b) The predicted duality relation between the s-channel (baryon) and the t-channel (meson) Regge poles is not supported quantitatively. (c) Using the polynomial form for residue functions suggested by the model, detailed fits to all $\pi N$ backward data and elastic widths are performed. The model fails to provide an adequate extrapolation from the scattering data to the widths of the $\Delta_3(1238)$ and its recurrences; acceptable agreement is found for the other trajectories. Moreover, the residues of the $\pi N$ trajectories are in marked disagreement with exchange degeneracy. (d) Within a factor of 2 in amplitude, the model reproduces available KN charge-exchange data from threshold to the highest energy. (e) A Pomeranchuk trajectory with normal slope ($\alpha_P' \approx 1$ GeV$^{-2}$) is consistent with both the Veneziano model and all data. (f) The model does not provide any natural resolution of the difficulties inherent in classical Regge-pole model fits, and thus supports the view that Regge cuts are important. (auth)

**18208** INFINITELY DEGENERATE LEADING BARYON TRAJECTORY. Freund, Peter G. O.; Waltz, Ronald (Univ. of Chicago). Phys. Rev.; 188: 2270-3(25 Dec 1969).

In the quark model, the leading baryon trajectory is resolved into infinitely many degenerate trajectories. An exchange-degeneracy pattern of periodicity $\Delta J = 6$ is obtained. At finite physical values of the spin, only a finite number (increasing with the spin) of these infinitely many trajectories support particles. A general hadronic mass formula is proposed. (auth)

**18209** ADDITIONAL RELATIONS BETWEEN SPIN-DENSITY MATRIX ELEMENTS. Thews, Robert L. (Univ. of Rochester, N. Y.). Phys. Rev.; 188: 2264-70(25 Dec 1969).

The spin structure of amplitudes for the joint production of a baryon and meson resonance of arbitrary spins was investigated. Both meson-nucleon and photon-nucleon interactions were considered. If the production is dominated by the exchange of a single set of quantum numbers, relations between spin-density matrix elements exist in some cases and provide an experimental test for this mechanism. Comparisons with data are given for some reactions. (auth)

**18210** GAUGE-FIELD CHIRAL LAGRANGIAN. Schechter, J. (Syracuse Univ., N. Y.); Ueda, Y. Phys. Rev.; 188: 2184-95 (25 Dec 1969).

The $SU(3) \times SU(3)$ chiral Lagrangian with gauge fields is discussed, including a consideration of SU(3)-symmetry breaking. In addition to details of the formulation, applications to $\pi$-N scattering lengths, $K^+$-N scattering lengths, and semileptonic decays are treated. The S-wave $\pi$-N scattering lengths are found to be independent of the vector-meson-dominance assumption. A possible "improvement" of the calculation by adding the N* particle is also discussed. The $K^+$-N S-wave scattering lengths can be calculated in good agreement with experiment when all symmetry breaking (including $\omega$-$\phi$ mixing) is put into the mass terms of the physical particles and it is assumed that the physical $\phi$ particle decouples from the nucleons. Alternative SU(3)-breaking schemes are investigated and, for a modified mass-term mixing model, the renormalizations to the Cabibbo theory for all semileptonic decays can be correlated in terms of one (known) parameter. (auth)

**18211** VENEZIANO-TYPE REPRESENTATION FOR $\pi$N AMPLITUDES. Chu, Chu-yuan; Desai, Bipin R. (Univ. of California, Riverside). Phys. Rev.; 188: 2215-17(25 Dec 1969).

A Veneziano-type representation for $\pi$N amplitudes is written in which the parity partners of the nucleon and the 3-3 resonance are absent. The difficulty in the earlier models of having $\Delta$ trajectories in N channel (and vice versa) is avoided. The parameters in our model are determined from low-energy data; the prediction for intermediate-energy resonances and high energy forward charge-exchange scattering are within a factor of 2 of the experimental values. (auth)

**18212** DYNAMICAL CALCULATION OF THE $\frac{3}{2}^+$ RESONANCE SPECTRUM AND SU(3) SYMMETRY BREAKING. Katz, J.; Wagner, S. (Univ., Hamburg). Phys. Rev.; 188: 2196-2208(25 Dec 1969).

The multichannel relativistic Schrödinger equation is solved for the $\frac{3}{2}^+$ partial-wave amplitude with an energy-dependent potential obtained by computing the baryon exchange contribution to pseudoscalar-meson-baryon scattering. Since a cutoff parameter is not needed in the calculations, the coupling constant is used as an adjustable parameter. Thus $g^2/4\pi = 38$ is used in order to obtain the N*(1236) at the correct experimental energy. The model yields the usual $\frac{3}{2}^+$ decuplet and predicts in addition the existence of a 27-dimensional SU(3) representation [to which $P_{33}(1690)$, $P_{13}(1860)$, $Z_1(1900)$, and some higher $\Sigma^*$, $\Xi^*$, and $\Lambda^*$ resonances could belong] as well as a second decuplet at much higher energies. Certain resonances ("exotic" ones with $I = 2$, $Y = 0$; $I = \frac{3}{2}$, $Y = -1$; and $I = 1$, $Y = -2$) are very broad ($\approx$1000 MeV); others (the usual ones including the exotic $I = 1$, $Y = 2$ KN resonance) have a width $\leq$400 MeV. The dependence of the resonance spectrum on the breaking of SU(3) symmetry as well as on the coupling constant and on the F/D ratio is discussed. A value of the F/D ratio of about 0.4 seems the best fit to experiments. The results are compared with the $\frac{3}{2}^+$ predictions of other models such as N/D calculations, quark model, strong-coupling theory, and SU(3)" symmetry. In the two last-named models, a 27 appears also as a higher supermultiplet, which is forbidden in the quark model. Additional octets and $\overline{10}$ representations [predicted also by SU(3)" and the quark model] are obtained as unphysical objects in our calculation. (auth)

**18213** THE DUALITY BETWEEN DIRECT-CHANNEL RESONANCES AND REGGE EXCHANGES. Schmid, C. (CERN, Geneva). pp 747-62 of Theory and Phenomenology in Particle Physics. Part B. /Zichichi, A. (ed.). New York; Academic Press Inc. (1969).

The extent to which direct-channel resonances are already contained in the Regge exchange amplitude is considered. The sequence of prominent and well-established πN resonances is mainly discussed, and the charge-exchange amplitude is stressed primarily. (J.F.P.)

**18214** SUPERCONVERGENCE SUM RULES FOR BACKWARD MESON–BARYON SCATTERINGS. Sharma, M. C.; Seth, V. P.; Agarwal, B. K. (Allahabad Univ., India). J. Phys., A (London); 3: 175-9(Mar 1970).

Superconvergence sum rules for the $\overline{K}N \to \overline{K}N$ elastic process and the $\overline{K}\Lambda \to \overline{K}\Sigma$ inelastic process are constructed and tested by saturating them with the low-lying intermediate states. A value for N*(1470)KΛ coupling is calculated. (auth) (UK)

**18215** LORENTZ POLE ANALYSIS OF THE REACTION $\pi^+n \to \omega p$. Rao, A. Srinivas (Osmania Univ., Hyderabad, India). J. Phys., A (London); 3: 166-9(Mar 1970).

The high-energy behavior of the reaction $\pi^+n \to \omega p$ was analyzed in terms of the O(3,1) symmetry formalism. A good fit to the experimental data are obtained by choosing a ρ′ trajectory in addition to the ρ trajectory, with the assumption that $\alpha_{\rho'} = \alpha_\rho - 1$. It is found that the ρ′ trajectory belongs to the Lorentz quantum numbers $j_0 = 0$ and $j_0 = 1$. (auth) (UK)

**18216** UNITARY SYMMETRY AND SUPERCONVERGENCE RELATIONS. Seth, V. P.; Sharma, M. C.; Agarwal, B. K. (Allahabad Univ., India). J. Phys., A (London); 3: 170-4(Mar 1970).

Superconvergent sum rules were constructed for the linear combination of invariant amplitudes for meson–baryon elastic scatterings and tested them by saturating with the low-lying intermediate states. (auth) (UK)

**18217** VENEZIANO MODEL FOR THE ρ CONTRIBUTION TO THE NUCLEON FORM FACTORS. Antoniou, N. G.; Bartl, A.; Widder, F. (Univ., Tuebingen, Ger.). Z. Phys.; 232: 390-7 (1970).

The Igi-Veneziano model for πN scattering, combined with the experimental pion form factor is used to study the ρ contribution to the isovector electromagnetic nucleon form factors. (auth)

**18218** A ONE-CHANNEL N/D CALCULATION OF THE πN PARTIAL WAVES INCORPORATING INELASTIC UNITARITY. Hung, E. K. L. (Univ. of Alberta, Edmonton). Z. Phys.; 232: 363-73(1970).

A re-analysis is made of the $J \leq \frac{5}{2}$ πN partial waves in a single channel N/D scheme. The new features are inclusion of (i) inelastic unitarity, and (ii) the forces generated by the exchange of a scalar I = 0 meson. The calculation shares the same difficulties with other one-channel treatments in that (a) the $D_{13}$ resonance is absent, and (b) it is not possible to produce the nucleon as a dynamical bound state and at the same time obtain a $P_{11}$ resonance. Apart from these $S_{11}$, $P_{11}$ and $D_{13}$ waves, good agreement can be obtained between theory and experiments in other partial waves. (auth)

**18219** NEUTRON–PROTON MASS DIFFERENCE BY AN S-MATRIX METHOD. Heiko, Lance Kenneth. Waltham, Mass.; Brandeis Univ. (1969). 124p.

Thesis.

The neutron-proton mass difference is calculated in the framework of the bootstrap theory of symmetry-breaking. An S-matrix perturbation method that is both static and cutoff dependent is derived. The method permits both mass and residue shifts to enter into calculations. In the calculation of the neutron-proton mass difference the feedback of mass and residue shifts is capable of reversing the negative contribution of one photon exchange. The mass difference, however, cannot be accounted for in terms of mass shift feedback alone. The reduction factors for Δ exchange which are necessary to obtain the mass difference are discussed in detail. (Diss. Abstr.)

**18220** SOME $SU(6)_w$ INVARIANT SCATTERING AND DECAY AMPLITUDES. Head, Martha Ella. New Orleans; Tulane Univ. (1969). 273p.

Thesis.

The techniques of $SU(6)_w$ are used to obtain scattering matrix elements for some collinear relativistic processes involving pseudoscalar mesons, baryons, and baryon resonances. A general method of calculating $SU(6)_w$ invariant scattering matrix elements by Clebsch–Gordan techniques is discussed. This method is applied to scattering processes with an initial state consisting of a pseudoscalar meson and a baryon and with a final state of a pseudoscalar meson and a baryon resonance. Other scattering amplitudes are presented in terms of the SU(3) Clebsch–Gordan coefficients. Experimental data for the scattering processes are sparse. However, the results of this calculation are compared with the available information using the optical theorem to convert predictions of forward scattering amplitudes to total cross sections. Agreement is reasonably good. Decay amplitudes for some baryon resonances are also calculated. These resonances are treated as a composite of a parent baryon resonance and a vector spin spurion assigned to the $1^1$ of an SU(6) 35. The decay branching ratios predicted are compared with experimentally observed ratios. Agreement with experiment is reasonable for several states of a spin $\frac{1}{2}^-$ octet and a spin $\frac{3}{2}^-$ octet of baryon resonances. This comparison indicates that the 70 channel is dominant for the processes discussed. (Diss. Abstr.)

**18221** EXCHANGE-DEGENERATE REGGE TRAJECTORIES AND MESON–NUCLEON CHARGE-EXCHANGE SCATTERING. Ahmadzadeh, Akbar; Kaufmann, William B. (Univ. of California, Berkeley, Arizona State Univ., Tempe). Phys. Rev.; 188: 2438-42(25 Dec 1969).

Based on exchange degeneracy and SU(3) symmetry, a Regge-pole model fitting the differential cross sections for pion-nucleon and kaon-nucleon charge exchange and η production as well as polarization in $\pi^-p \to \pi^0n$ is given. Besides the ρ-$A_2$ trajectory, a conspiring and exchange-degenerate ρ′-$A_2'$ trajectory with the same slope as ρ-$A_2$ but with an intercept near zero is taken into account. The residues are assumed to have $1/\Gamma(\alpha)$ behavior. A four-parameter fit gives good agreement with the experimental data. (auth)

## *Strong (Baryon No. ≥ 2)*

**18222** (INP–686) POSSIBILITIES OF USING NUCLEAR TARGETS IN INVESTIGATIONS OF HADRONIC INTERACTIONS AT HIGH ENERGIES. Czyz, W. (Institute of Nuclear Research, Krakow (Poland)). 1969. 17p. (CONF-690914–6). Dep. CFSTI (U. S. Sales Only).

From 3rd International Conference on High Energy Physics and Nuclear Structure, New York.

Interference between the Coulomb and strong interactions in the hadron-nucleus elastic scattering amplitudes is employed to extract the ratio of the real to imaginary part of the hadron-nucleon elastic scattering amplitude. Comparison with the 20 GeV proton-nuclei elastic and almost elastic scattering data is given. (auth)

**18223** THE PRODUCTION CHARACTERISTICS OF THE REACTION $pp \to pn\pi^+$ AT 7 GeV/c. Lyons, L. (Weizmann Inst. of Science, Rehovoth, Israel). Nucl. Phys.; B15: 355-64(1970).

The peripheral features of the reaction $pp \to pn\pi^+$ at 7 GeV/c are investigated. Especially those distributions which are sensitive to the model are compared with the predictions of a double-Regge-exchange mechanism. The observed Treiman-Yang distributions are qualitatively consistent with the relevant exchanges being the pion and Pomeron trajectories. (auth)

**18224** REGGE-POLE MODEL WITH THE DIFFRACTIVE CORRECTION. II. pn AND $p\bar{p}$ CHARGE EXCHANGE SCATTERING. Biyajima, Minoru; Watanabe, Tsunetoshi (Tokyo Univ. of Education). Progr. Theor. Phys. (Kyoto); 42: 1329-35 (Dec 1969).

The pn and $p\bar{p}$ charge exchange scattering are discussed in terms of the Regge pole model with the diffractive correction along the line of previous papers on the $\pi^s$ photoproduction. A fairly good fit is obtained for the differential cross section (pn – np scattering at $p_L = 8$ GeV/c) and further the polarization and depolarization are predicted, which provide the test to our diffractive correction theory. (auth)

**18225** REGGE CUTS, MULTIPLE SCATTERING, AND THE POMERON SLOPE. Koelbig, K. S.; Margolis, B. (McGill Univ., Montreal). Phys. Lett.; 31B: 20-1(5 Jan 1970).

The Dubna–Serpukhov small momentum transfer data on p-p elastic scattering are analyzed in terms of the moving-pomeron-plus-cuts model of Frautschi et al. Evidence is found for a pomeron slope $\alpha_p' \approx 1$ (GeV/c)$^{-2}$. (auth)

**18226** APPLICATION OF MULTI-REGGE THEORY TO PRODUCTION PROCESSES AND HIGH-ENERGY MODEL FOR PROTON–PROTON SCATTERING. Lipes, Richard Gwin. Pasadena, Calif.; California Inst. of Tech. (1969). 109p.

Thesis.

This dissertation consists of two parts. The first part presents an explicit procedure for applying multi-Regge theory to production processes. As an illustrative example, the case of three body final states is developed in detail, both with respect to kinematics and multi-Regge dynamics. Next, the experimental consistency of the multi-Regge hypothesis is tested in a specific high energy reaction; the hypothesis is shown to provide a good qualitative fit to

the data. In addition, the results demonstrate a severe suppression of double Pomeranchon exchange, and show the coupling of two "Reggeons" to an external particle to be strongly damped as the particle's mass increases. Finally, with the use of two body Regge parameters, order of magnitude estimates of the multi-Regge cross section for various reactions are given. The second part presents a diffraction model for high energy proton-proton scattering. This model developed by Chou and Yang assumes high energy elastic scattering results from absorption of the incident wave into the many available inelastic channels, with the absorption proportional to the amount of interpenetrating hadronic matter. The assumption that the hadronic matter distribution is proportional to the charge distribution relates the scattering amplitude for pp scattering to the proton form factor. The Chou-Yang model with the empirical proton form factor as input is then applied to calculate a high energy, fixed momentum transfer limit for the scattering cross section. This limiting cross section exhibits the same "dip" or "break" structure indicated in present experiments, but falls significantly below them in magnitude. Finally, possible spin dependence is introduced through a weak spin-orbit type term which gives rather good agreement with pp polarization data. (Diss. Abstr.)

**18227** BEHAVIOR OF BARYON–BARYON AND BARYON–ANTIBARYON TOTAL CROSS SECTIONS AT HIGH ENERGY. Rosner, Jonathan (Univ. of Minnesota, Minneapolis); Rebbi, Claudio; Slansky, Richard. Contracts AT(11-1)-68; AT(11-1)-1764. Phys. Rev.; 188: 2367-77(25 Dec 1969).

The energy-dependent parts of baryon-baryon and baryon-antibaryon total cross sections at high energies are obtained from (i) factorization of the residues of the leading meson trajectories, and (ii) the connection between the absence of resonances in "exotic" channels and the flatness of meson-meson and meson-baryon total cross sections in these channels. (Such a connection leads to exchange degeneracies, all of which are consistent with experiment.) The following is proven: (a) Nucleon-nucleon (and certain other B = 2) total cross sections are flat whether or not trajectory couplings obey SU(3); (b) the remaining B = 2 cross sections are flat if tensor and vector exchanges couple via SU(3), with equal F/D ratios at the baryon vertex; (c) non-Pomeranchuk contributions to baryon-antibaryon total cross sections persist in the 10, $\overline{10}$, and 27 channels despite the relaxation of assumptions regarding B = 2 systems. [Results similar to (a) and (b) have been assumed to hold in previous approaches.] (auth)

**18228** REGGE-POLE MODEL OF ELASTIC LARGE-ANGLE SCATTERING AT HIGH ENERGIES. Masuda, Naohiko (Univ. of Wisconsin, Madison. Louisiana State Univ., Baton Rouge); Mikamo, Shoji. Phys. Rev.; 188: 2176-83(25 Dec 1969).

The effect of the Regge-pole-like structure of an amplitude in the small-angle region on the behavior of the high-energy elastic large-angle scattering is studied by linearizing the nonlinear equation for the imaginary part of the amplitude derived from the unitarity relation. It is shown that the slope of the elastic large-angle differential cross section for antiparticle-particle scattering should be always less steep than that of large-angle particle-particle scattering, contrary to the situation in the small-angle region. Using the general formula for the elastic large-angle scattering obtained in this paper, the existing experimental data on the $\bar{p}p$ and pp differential cross sections at large angles are numerically analyzed. With regard to the logarithmic slopes of the differential cross sections, it is found that this model can reproduce the gross structure of the experimental data on both $\bar{p}p$ and pp processes. The prediction that the slope of the $\bar{p}p$ large-angle scattering cross section will be less steep than that of pp is also confirmed experimentally. The dip and bump structures in experimental differential cross sections are compared with the theoretical prediction of oscillations in the differential cross section. (auth)

**18229** $\Lambda-\Sigma$ CONVERSION IN LOW-ENERGY $\Lambda$d SCATTERING. Schick, L. H. (Univ. of Southern California, Los Angeles). Phys. Rev.; 188: 2089-91(25 Dec 1969).

Nonlocal separable potentials are used to represent the $^3S_1$ np and the $^3S_1$ isospin-$\frac{1}{2}$ YN (Y = $\Lambda$, $\Sigma$) potentials. For different sets of YN potential parameters, both $\Lambda$N triplet cross sections far below the $\Sigma$N threshold and $\Lambda$d quartet cross sections far below the $\Sigma$NN threshold are calculated. The $\Lambda$d cross sections are much more sensitive to the coupling of the $\Lambda$N and $\Sigma$N channels as well as to the presence of a $\Lambda$N resonance. (auth)

**18230** REGGE CUT CORRECTIONS TO REGGE-POLE EXCHANGE. Frautschi, Steven (California Inst. of Tech., Pasadena). pp 701-12 of Theory and Phenomenology in Particle Physics. Part B. /Zichichi, A. (ed.). New York; Academic Press Inc. (1969).

An alternative approach to Regge cuts, which was proposed previously, is considered. In this approach the difficulties of calculating complicated diagrams are circumvented by assuming that Regge cuts correspond to multiple scattering. In this way the cuts can be estimated by means of a previous multiple scattering formalism. The breaks in p + p → p + p differential cross sections, the crossover between the differential cross sections for $\pi^-$ + p → $\pi^-$ + p and $\pi^+$ + p → $\pi^+$ + p interactions, and the forward spike in n + p → n + p interactions are considered. (J.F.P.)

**18231** PROTON–NEUTRON SCATTERING. Straumann, N. (Univ., Zurich. Schweizerisches Institut fuer Nuclearforschung, Zurich); Wilkin, C. Phys. Rev. Lett.; 24: 479-83(2 Mar 1970).

Using Glauber multiple-scattering theory, the missing-mass spectrum for protons scattered off a deuterium target is computed. The relatively clean separation of the single- and double-scattering peaks offers the possibility of determining the high-energy proton–neutron differential cross section. (auth)

**18232** APPLICATION OF WEIZSAECKER–WILLIAMS METHOD TO HIGH-ENERGY NUCLEON–NUCLEON COLLISIONS. Murai, Moriyasu; Kakudo, Yujiro (Osaka Kyoiku Univ.). Mem. Osaka Kyoiku Univ.; 17: No. 1, 19-31(1968).

By application of the Weizsäcker–Williams method to the nucleon-nucleon collision in multi GeV range, the proton-proton total inelastic cross sections and the pion angular distribution in the process p + p → $\pi$ + n + p are obtained. The results are compared with the two prongs events in nuclear emulsion at incident energies E = 5 GeV and 10 GeV. On the basis of this comparison, a speculation is given about the mechanism for the double pion production process. (auth)

**18233** RECONSTRUCTION OF $\Lambda-N$ INTERACTION FROM THE EXACT SOLUTION OF THE FADDEEV EQUATIONS FOR HYPERTRITIUM. Akhmadkhodzhaev, B. (Inst. of Nuclear Physics, Tashkent); Belyaev, V. B.; Wrzecionko, E. JETP Lett. (USSR) (Engl. Transl.); 10: 356-8(20 Dec 1969).

Translated from Zh. Eksp. Teor. Fiz. Pis'ma Redaktsiyu; 10: 57-61(5 Dec 1969).

An analysis of the $\Lambda-N$ interaction based on a numerical solution of the Faddeev equations for hypertritium is given. The parameters of the $\Lambda-N$ interaction are chosen to represent the experimental value of the hypertritium binding energy and the variation of the $\Lambda-p$ scattering cross section at low energy. Sets of the $\Lambda-N$ potential parameters are given leading to the best agreement between data on the cross section for elastic $\Lambda-p$ scattering with $B_\Lambda$ = 0.18 MeV for hypertritium. Also results of the calculation of $\Lambda-p$ scattering in the effective-radius approximation for s-waves are shown. (J.F.P.)

**18234** HIGH-ENERGY NUCLEON–NUCLEON SCATTERING. Hoshizaki, Norio (Kyoto Univ.). Progr. Theor. Phys. (Kyoto), Suppl.; No. 42, 1-38(1968).

A review is presented of high-energy nucleon–nucleon scattering. This review covers nucleon–nucleon phase shifts below 400 MeV and the formulation of the method of analysis above 400 MeV, nucleon–nucleon phase shifts from 400 MeV to 1 GeV, and methods and results of analysis above 1 GeV. Also treated are results from 400 MeV to 3 GeV and nucleon–nucleon phase shifts above 10 GeV. (J.F.P.)

**18235** FORMALISM OF NUCLEON–NUCLEON SCATTERING. Hoshizaki, Norio (Kyoto Univ.). Progr. Theor. Phys. (Kyoto), Suppl.; No. 42, 107-59(1968).

The formalism of nucleon–nucleon scattering covers nonrelativistic formalism, relativistic treatment in some detail, and the angular momentum representation and its relation to the helicity–amplitude formalism. (J.F.P.)

# Particle Invariance Principles and Symmetries

## General

*Refer also to abstracts 18210 and 18310.*

**18236** THE POINCARE GROUP AND THE $\Lambda$-REPRESENTATION. Braathen, Hans J. (Case Western Univ., Cleveland). Contract AT(11-1)-1573. Nucl. Phys.; B15: 477-500(1970).

A basis where an attempt was made to take into account the special azimuthal symmetry in scattering experiments, and which is of importance in crossing symmetry, is defined. The basis is chosen such that the energy, the third components of the momentum and the angular momentum are diagonal together with the helicity. The Poincaré algebra is represented in this basis. A

particular spin algebra, defined in a previous article is utilized in the construction of the representation. The discrete elements of the Poincaré group are also represented. The basis is very well suited for discussing the singularities which come from the definition of the helicity itself. The connection between our basis and that defined by Jacob and Wick is given. The zero-mass case is discussed and it is proven that in this representation the discrete case of zero mass is identical with the limit of the continuous positive-mass case. (auth)

**18237** REALIZATIONS OF LIE ALGEBRAS WITH PARAFIELD OPERATORS. Kademova, K. (International Atomic Energy Agency, Trieste, Italy). Nucl. Phys.; B15: 350-4(1970).

A realization of any Lie algebra is given in terms of second-order polynomials of Green-algebra generators. An example of the realization of some class of representations of the Lie algebra in a suitably chosen linear space is also given. (auth)

**18238** NOTE ON A CLASS OF CG COEFFICIENTS OF SU(3). Majumdar, S. Datta (Indian Inst. of Tech., Kharagpur, India). Progr. Theor. Phys. (Kyoto); 42: 1475-6(Dec 1969).

It is pointed out that an analogous expression to the one previously obtained for the general isocalar factor of SU(3) (S. D. Majumdar, Prog. Theor. Phys., 41: 1382 (1969)) can be derived without restrictions on the values of the isotopic spins. (L.B.S.)

**18239** ASYMPTOTIC $SU(6)_W$ SPECTRAL SUM RULES. I. FORMULATION. Okubo, Susumu (Univ. of Rochester, N. Y.). Phys. Rev.; 188: 2293-2300(25 Dec 1969).

Spectral sum rules on the basis of asymptotic $SU(6)_w$ symmetry are given. It is shown that the $SU(6)_W$ group is likely to be a reasonably good asymptotic symmetry as far as the two-point function is concerned. (auth)

**18240** EXTENSION OF SUGAWARA'S THEORY OF CURRENTS. Ahmed, M. A.; Taha, M. O. (Univ. of Khartoum, Sudan). Phys. Rev.; 188: 2517-21(25 Dec 1969).

Sugawara's theory of currents is extended to allow for the nonconservation of the axial-vector currents. This is done by extending the set of independent dynamical variables to include, beside the vector and axial-vector currents, the divergences of the axial-vector currents, and suitably modifying the form proposed by Sugawara for the stress-energy tensor. For SU(2) ⊗ SU(2) a series solution is obtained for the equal-time commutator of the axial-vector current and its divergence. (auth)

**18241** SPIN AND INTERNAL SYMMETRY IN DUAL FEYNMAN THEORY. Halpern, M. B. (Univ. of California, Berkeley); Klein, S. A.; Shapiro, J. A. Phys. Rev.; 188: 2378-84(25 Dec 1969).

Spin and internal symmetry are incorporated into the recently proposed dual Feynman theory. Classification of all graphs via the sewing procedure is emphasized, and it becomes explicit that the $\tilde{U}(12)$ theory keeps its symmetry (and its ghosts) to all orders. The pattern of the breakdown of exchange degeneracy is also discussed. (auth)

**18242** CURRENT ALGEBRAS AS UNITARY REPRESENTATIONS OF GROUPS. Goldin, Gerald A. Princeton, N. J.; Princeton Univ. (1969). 243p.

Thesis.

It is possible that a complete physical theory can be written entirely in terms of operators such as current densities, rather than in terms of field operators. Models for nonrelativistic quantum mechanics, for charged scalar mesons, for quarks, etc., are reviewed, in which the equal-time current commutators, obtained heuristically from canonical field commutation or anticommutation relations, are taken as the starting point of a new theory. The current densities in these models correspond in general to distributions of unbounded operators in a Hilbert space H. It is found that one can exponentiate the current algebras to obtain groups, which may then be represented by unitary (hence bounded) operators in H. The groups are displayed for each of five recently studied models. Each group contains a maximal abelian subgroup which is a nuclear space. The Gel'fand–Vilenkin formalism for "nuclear Lie groups" is found to be superior to the spectral theory of commutative C*-algebras, for the representation theory of the groups obtained. The representation theory is used to rigorize the non-relativistic theory in a box. The currents themselves can be expressed as multiplication and differentiation operators on a certain space of functions of infinitely many complex variables. (TSS) (Diss. Abstr.)

**18243** DEFORMATIONS OF LIE ALGEBRAS AND RELATIVIZATION OF THE INTERNAL SYMMETRY. THE CASE OF SEMISIMPLE ALGEBRAS. Lyakhovskii, V. D. Vestn. Leningrad. Univ., Fiz., Khim.; No. 10, 45-51(May 1969). (In Russian).

The problem of relativization of internal symmetry and its connection with the theory of deformations of Lie algebras is discussed. It is shown that all the deformations of the direct sum of Poincaré algebra and semisimple internal symmetry algebra S necessarily contain the direct summand S. (auth)

**18244** PROJECTIVE UNITARY ANTIUNITARY REPRESENTATIONS OF LOCALLY COMPACT GROUPS. Parthasarathy, K. R. (Univ. of Manchester, Eng.). Commun. Math. Phys.; 15: 305-28(30 Dec 1969).

A systematic presentation of the theory of projective representations when antiunitary operators are present is given. In particular the imprimitivity theorem of Mackey is proved in this situation and all the unitary antiunitary representations of the extended Poincaré group are derived. (auth)

## *Applications (Electromagnetic and Weak)*

**18245** (CONF-690330–, pp 96-102) REVIEW OF THE EXPERIMENTAL SITUATION RELEVANT TO CP VIOLATION. Steinberger, J. (European Organization for Nuclear Research, Geneva (Switzerland)).

This review of CP violation covers meson ($K^0$) → $2\pi$ decay, charge asymmetry in $K_L^0 \rightarrow e^\pm (\mu^\pm) + e^\pm + \nu$ decay, the superweak model for $2\pi$ decay, superweak versus milliweak or millistrong. CPT and T invariance in the weak interaction are also considered. It is noted that the CP violation effects thus far observed are all of the order of $2(10)^{-3}$ in amplitude and are limited to $K^0$ decay. (J.F.P.)

**18246** C-VIOLATION IN η-DECAY? Frenkel, A. (Central Research Inst. for Physics, Budapest); Vesztergombi, G.; Marx, G. Nucl. Phys.; B15: 429-41(1970).

The recent experimental results on the charge asymmetry in η-decay were compared with a theoretical model of C-violation. Five asymmetry parameters of the $\eta \rightarrow \pi^+\pi^0\pi^-$ energy distribution were defined and their measured values were reproduced by the model within one standard deviation. The implication of the experimental upper limit on the $\eta \rightarrow \pi^0 e^+ e^-$ decay was also taken into account. Order of magnitude estimates indicate that the model is not in contradiction with the experimental results on the $K_L$ decay. (auth)

**18247** CURRENT-DENSITY–CURRENT-DENSITY COMMUTATORS AND THE DECAYS OF $\pi^0$ AND ω. Sakuraoka, Mitsuru (Tohoku Univ., Sendai). Progr. Theor. Phys. (Kyoto); 42: 1361-71(Dec 1969).

It has been shown that the PCAC and the algebra-of-field commutation relations forbid the decays of $\pi^0$ and ω mesons. A model based on phenomenological U(2) ⊗ U(2) invariant Lagrangian which is consistent with the $A_1\rho\pi$ and $\omega\rho\pi$ systems is proposed. The PCAC holds, while the local U(2) ⊗ U(2) gauge invariance breaks down so that the equal-time space-time- and space-space-current-density commutation relations are modified from that of gauge-field-algebra. The unknown constant arising from the new term relevant to $\omega\rho\pi$ coupling is fixed by feeding the measured value of the decay $\pi^0 \rightarrow 2\gamma$. Then the results obtained for the widths $\Gamma(\omega \rightarrow \pi^0 + \gamma)$ and $\Gamma(\omega \rightarrow 3\pi)$ are in good agreement with experiment. The alternative model which maintains field-current identity but breaks down the PCAC (this is equivalent to the model of Arnowitt et al.) is also investigated and compared with the previous results. (auth)

**18248** REGGE POLES FOR COULOMB POTENTIAL FROM THE DYNAMICAL SO(4,2) THEORY. Morita, Katsusada; Tsuzuki, Katsutoshi (Nagoya Univ., Japan). Progr. Theor. Phys. (Kyoto); 42: 1418-21(Dec 1969).

Within the framework of SO(4,2) theory for the Schrödinger H-atom it will be shown here that Regge poles appear in the partial-wave S-matrix through analytic continuation (into complex Casimir values) of unitary irreducible representation (UIR) of the positive discrete class of a particular subgroup SO(2,1) of SO(4,2). (auth)

**18249** FOUR-BARYON WEAK INTERACTIONS WITH ΔS = 1 and SU(6) SYMMETRY. Nikiforov, B. P.; Filimonov, V. A. Tomsk Polytechnic Inst., USSR). Izv. Vyssh. Ucheb. Zaved., Fiz.; No. 10, 70-7(1969). (In Russian).

Relations among amplitudes of four-baryon processes with ΔS = 1 were obtained assuming that the Lagrangian of s-wave weak interactions has the transformation properties of a 35-plet component of SU(6). (R.V.J.)

**18250** $SU_2$ X $SU_3$ REPRESENTATION MIXING AND ELECTROMAGNETIC FORM FACTORS. Love, A.; Moorhouse, R. G. (Univ. of Glasgow). Phys. Rev.; 188: 2313-18(25 Dec 1969).

A two-representation description of the stable baryons is pre-

sented in which the isoscalar Pauli form factor of the nucleon vanishes. With the further assumption that $N^*(1236)$ electroproduction is pure M1, the isovector Pauli form factor of the nucleon and the form factor for $N^*(1236)$ electroproduction have the same shape. The mixing of the stable baryons with higher resonances is discussed. (auth)

**18251** COULOMB GROUP THEORY FOR ANY SPIN. Jordan, T. F.; Pratt, R. H. (Univ. of Pittsburgh). Contract AT(30-1)-3829. Phys. Rev.; 188: 2534-5(25 Dec 1969).

For any spin, the Coulomb bound states can be described by an irreducible unitary representation of O(4,1). The relativistic Coulomb problems that have been solved (spins 0 and ½) are described in this way. (auth)

**18252** VIOLATION OF THE $\Delta I$ ABSOLUTE VALUE = ½ RULE IN THE $K_{3\pi}$ DECAY. Matsuda, S.; Oppo, Giuseppe (Polytechnic Inst. of Brooklyn). Phys. Rev.; 188: 2308-11(25 Dec 1969).

Recent experimental results reveal the presence of a large $|\Delta I| = 3/2$ amplitude in the $K_{3\pi}$ decay. The relevant information is contained in the four 3-pion ratios $R_1 \equiv 3/2\gamma^{000}/\gamma^{+-0}$, $R_2 \equiv 1/\gamma^{+-}/\gamma^{+00}$, $R_3 \equiv 1/2\gamma^{+-0}/\gamma^{+00}$, and $R_4 \equiv \gamma^{000}/(\gamma^{+-}-\gamma^{+00})$, which are all equal to 1 in the exact $|\Delta I| = 1/2$ limit (the $\gamma$'s are partial decay widths divided by phase-space factors, and the superscripts +, −, and 0 indicate positive, negative, and neutral pions, respectively). It is found that the deviations of the ratios $R_3$ and $R_4$ from the exact $|\Delta I| = 1/2$ value are of the order of 20%, whereas the deviation is small for the ratios $R_1$ and $R_2$. A survey of the experimental situation in nonleptonic weak decays shows that in some cases the $|\Delta I| = 1/2$ rule seems to be almost exact, whereas in others it is clearly violated. One possible theoretical approach assumes that the primary weak interaction can give rise only to $|\Delta I| = 1/2$ transitions if the electromagnetic interactions are discarded, and explains the $|\Delta I| \neq 1/2$ amplitudes by electromagnetic corrections. In this framework, it is shown that the whole $|\Delta I| \neq 1/2$ amplitude in the $K_2^0 \to 3\pi$ decay may be obtained by virtual electromagnetic corrections. It is shown that the $\eta^0$-$X^0$ mixing plays a rather important role. An order of magnitude estimate of the $\Gamma(X^0 \to 3\pi)$ width is also obtained, which is compatible with the experimental upper limit. (auth)

**18253** CP VIOLATION IN $K_L^0$ DECAY. Schwartz, M. (Stanford Univ., Calif.). pp 583-613 of Theory and Phenomenology in Particle Physics. Part B. Zichichi, A. (ed.). New York; Academic Press Inc. (1969).

The experimental status concerning CP nonconservation in $K_2^0$ decay is reviewed. Some pertinent theoretical phenomenology is redeveloped, and CPT invariance is assumed throughout the discussion. The interference of $K_2^0$ with $K_1^0$, and the measurement of $|\eta_{00}|$ and of charge asymmetry in $K_2^0$ leptonic decay are considered. (J.F.P.)

**18254** IS THERE A CP VIOLATING $\Delta I = 3/2$ CURRENT IN THE $K_L^0$ DECAYS TO 2 PIONS? Lipman, N. (Rutherford High-Energy Lab., Chilton, Eng.). pp 615-45 of Theory and Phenomenology in Particle Physics. Part B. Zichichi, A. (ed.). New York; Academic Press Inc. (1969).

The meson ($K_2^0$) experiments and their bearing on whether there exists a direct CP violating amplitude in the $2\pi$ decay are discussed. The phenomenology and some other pertinent experiments are included. (J.F.P.)

**18255** CP-NONCONSERVING PARAMETER AND THE $\pi^+ - \pi^0$ ELECTROMAGNETIC MASS DIFFERENCE. Barshay, Saul (Univ. of Copenhagen). Phys. Rev. Lett.; 24: 490-3(2 Mar 1970).

An elementary calculation with Feynman graphs is used as a device for reproducing the $\pi^+ - \pi^0$ electromagnetic mass shift. Further use of this device makes possible a hypothetical calculation of the CP-nonconserving parameter $|\langle K_L|K_S\rangle| \cong |2\,\mathrm{Re}\epsilon|$ which yields the result $|2\,\mathrm{Re}\epsilon| \approx \delta(m_\pi^2)/2m_\rho^2 = (\delta m_\pi/m_\pi)(m_\pi/m_\rho)^2 \cong 1.2 \times 10^{-3}$. (auth)

## *Applications (Strong)*

*Refer also to abstracts 18212 and 18268.*

**18256** (CONF-690330–, pp 103-10) SYMMETRY BREAKING AND PHENOMENOLOGICAL LAGRANGIANS. Wess, J. (Karlsruhe Univ. (West Germany). Institut fuer Theoretische Physik).

In order to develop a formalism other than the usual concept of multiplets, which is not valid for the case of SU(2) × SU(2), the situation is reviewed with the addition of a $\sigma$, isoscalar, to make the basic multiplet complete. Lagrangian functions are considered. (J.F.P.)

**18257** SU(3) SYMMETRY BREAKING PARAMETER IN A QUARK MODEL. Kamal, A. N. (Univ. of Alberta, Edmonton). Nucl. Phys.; B15: 637-40(1970).

The spectral function sum rules derived in a recent paper were used to evaluate the symmetry breaking parameter c, the coefficient of $u_8$-term in the quark Lagrangian. If $\langle u_8 \rangle = 0$ (vacuum expectation value) then c is found to be $\approx -1.23$ with $F_\pi = F_K = F_\eta$. If experimental value for $F_K/F_\pi$ is used c is $-1.30 \pm 0.01$. However, if $u_8 \neq 0$ there is a solution with c small and of order $m_\pi^2/m_K^2$. (auth)

**18258** ALGEBRAIC METHOD IN THE STUDY OF RELATIVISTIC TWO-BODY PROBLEMS. PART I. BETHE-SALPETER EQUATION. PART II. QUASIPOTENTIAL EQUATIONS. Yang, Ying-Chuan. Los Angeles; Univ. of California (1969). 75p. Thesis.

The SO(4) Symmetry of the Bethe–Salpeter equation of Wick–Cutkowsky Model is studied in Minkowskian metric, and the hermiticity of generators of the SO(4) group is compared to the normalization condition of the BS equation. By introducing an SO(4,3) algebra, an algebraic form of the BS equation is presented. The solution is then compared to the classical ones. A new continuous spectrum was found which corresponds to the time-like separation of two particles. The trajectories of Lorentz poles are also discussed. The algebraic form of the quasipotential equation is given. An SO(4,2) algebra is used and the operators of the Poincare group are then shown. The algebraic equation is solved by the operator method. From the boundary condition discrete energy levels are shown. (Diss. Abstr.)

**18259** ASYMPTOTIC $SU(6)_W$ SPECTRAL SUM RULES. II. APPLICATIONS AND BARE QUARK MASSES. Okubo, Susumu (Univ. of Rochester, N. Y.). Phys. Rev.; 188: 2300-7(25 Dec 1969).

The sum rules of the first paper are investigated in detail in pole dominance. The ratio $f_K/f_\pi$ is found to be near unity and all nonexotic baryons must satisfy an approximate mass formula $M = a - bY$ with the universal constant $b \simeq m_3 - m_1 \simeq 150$ MeV, where $m_1$, $m_2$, and $m_3$ are masses of bare quarks. Moreover, $m_1 \simeq 7$ MeV and $m_3 \simeq 156$ MeV are computed in a model where SW(3) is exact except for the quark mass term. (auth)

**18260** CHIRAL $SU_3 \times SU_3$ FOR MESONS. Glashow, S. (Harvard Univ., Cambridge, Mass.). pp 713-21 of Theory and Phenomenology in Particle Physics. Part B. /Zichichi, A. (ed.). New York; Academic Press Inc. (1969).

The unification of the SU(3) and SU(2) × SU(2) groups for mesons is brought about by introducing the chiral SU(3) × SU(3). The obtained relations together with the Weinberg spectral function sum rules are discussed relative to leptonic decays of vector mesons and kaons. (J.F.P.)

**18261** RELATION BETWEEN NONLINEAR AND LINEAR REALIZATIONS OF CHIRAL SU(2) x SU(2). Rosen, S. P. (Univ. of Sussex, Eng.). Phys. Rev.; 188: 2542-4(25 Dec 1969).

It is shown that any nonlinear realization of SU(2) × SU(2) can be converted into a linear one of the type (j,j) by redefining the pion field. Explicit forms of the redefinition are derived for all values of j. (auth)

**18262** EXPERIMENTAL TESTS FOR THEORIES OF CHIRAL-SYMMETRY BREAKING. Dashen, Roger; Weinstein, Marvin (Inst. for Advanced Study, Princeton, N. J.). Phys. Rev.; 188: 2330-41(25 Dec 1969).

Assuming a picture of the strong interactions in which the Hamiltonian is the sum of an SU(3) ⊗ SU(3)-symmetric piece $H_0$ plus a small symmetry-breaking term $\epsilon H_1$, it is shown how to calculate relations among the corrections of order $\epsilon$ to the symmetry limit. The techniques are purely group-theoretic and involve no extraneous dynamical assumptions, so that the results provide direct experimental tests for various symmetry-breaking schemes. For example, it is shown that if $\epsilon H_1$ belongs to the $(3,\bar{3}) \oplus (\bar{3},3)$ representation of SU(3) ⊗ SU(3), then there is one sum rule satisfied by the corrections to the generalized Goldberger–Treiman relations for the three decays $n \to p + e + \nu$, $\Sigma \to N + e + \nu$, and $\Lambda \to N + e + \nu$. It is also shown that the so-called $\Sigma$ terms, which are closely related to $\epsilon H_1$, can be obtained from on-the-mass-shell scattering amplitudes (albeit at an unphysical energy point) if terms of order $\epsilon^2$ can be neglected in comparison to terms of order $\epsilon$. The question of whether or not lowest-order calculations of symmetry breaking are meaningful is discussed in some detail. (auth)

**18263** AN APPLICATION OF REGGE THEORY AND SU(3) REPRESENTATION MIXING TO HIGH-ENERGY REACTIONS SUGGESTING A SECOND $A_2$ MESON. Austin, Donald Murray. Iowa City, Iowa; Iowa State Univ. (1969). 95p. Thesis.

A mixing formalism for scalar fields carrying representations

of SU(3) is developed in a field-theoretic framework and extended to boson fields with spin. This formalism is applied to the twin-peaked $A_2$ mass distribution by assuming the existence of an isovector meson multiplet belonging to the 27-dimensional representation of SU(3) which is mixed with the usual tensor octet isovector $A_2$ in a manner such that the double peak occurs for some decay modes while a single peak may occur for others. Good fits to all of the relevant data are obtained. This theory is then Reggeized and used to fit the high energy cross section data for eta production by pions. An "averaged" fit to the direct channel resonance structure in the total cross section data is obtained by extrapolating the Regge amplitudes to the low energy region. Also, the Regge trajectories obtained from this calculation are shown to be in agreement with those required to explain the forward peak in pion photoproduction. The consequences of the duality hypothesis for an inelastic reaction are examined by partial wave analyzing the Regge amplitudes for eta pion-production. The Argand diagrams plotted from the resulting partial wave amplitudes are seen to represent families of direct channel resonances. These are compared to the resonance structure obtained from a similar analysis of $\pi$-N elastic scattering and to the low energy data. (Diss. Abstr.)

**18264** CERTAIN CONSEQUENCES OF THE CHIRAL SU(3) x SU(3) DYNAMICS. Sabo, V. I.; Sokur, L. P. (Uzhgorod State Univ., USSR). Izv. Vysah. Ucheb. Zaved., Fiz.; No. 11, 152-4(1968). (In Russian).

The effective Lagrangian function which is partially invariant with respect to the SU(2) × SU(2) type transformation group, defines satisfactorily the low-energy behavior of the $\pi$N system. This approach of I. Schwinger was generalized; the resulting SU(3) × SU(3) dynamics makes it possible to describe processes which take place not only with conservation but also with changes of strangeness. The problem is illustrated by examining the infinitesimal transformation of pseudoscalar mesons and baryons. It was found that within limits of experimental error the results of the SU(3) × SU(3) dynamics agree with experimental data of lepton decay processes. (TTT)

# Field Theories

## *Quantum Field Theory*

*Refer also to abstract 18241.*

**18265** (CNRS-CPT-69-P-317) ATTEMPT TO EVALUATE RENORMALIZED RADIATIVE CORRECTIONS BY COMPUTER. Calmet, J.; Perrottet, M. (Centre National de la Recherche Scientifique, Marseilles (France). Centre de Physique Theorique). [1968]. 27p. Dep. CFSTI (U. S. Sales Only).

An attempt is made to apply algebraic computational techniques to renormalization theory, by means of the programming language LISP. Programs that generate Feynman diagrams from the functional formalism for a scalar field as well as for quantum electrodynamics are described. Feynman integrals over the internal momenta are integrated within the $g\Phi^3$ scalar model and divergences of this superrenormalizable theory are removed. The numerical evaluation over Feynman parameters is made. (auth)

**18266** (ITF-69-75) PHENOMENOLOGIC INTERACTION LAGRANGIAN OF GOLDSTONE PARTICLES. Volkov, D. V. (Akademiya Nauk Ukrainskoi SSR, Kiev. Institut Teoreticheskoi Fiziki). 1969. 51p. (In Russian). (CONF-690417-24). Dep. CFSTI (U. S. Sales Only).

From 3rd Conference on Axiomatical Field Theory and Theory of Elementary Particles, Kiev, USSR.

The general scheme of the construction of phenomenologic Lagrangians for the arbitrary dynamic group theory is under consideration. (auth)

**18267** NEW FORMULATION OF QUANTUM ELECTRODYNAMICS. Fox, J. R. (Imperial Coll. of Science and Tech., London). Nucl. Phys.; B15: 413-28(1970).

Quantized electromagnetic field theory is formulated in terms of tensor potentials. None of the usual difficulties, such as indefinite metric or unphysical particles arises. Gauge considerations do not enter. The compatibility with axiomatic field theory is discussed. The fields interact locally with the electromagnetic current and the resultant quantum electrodynamics reproduces exactly the usual results. A similar solution to the problem of spin-2 graviton theory is indicated. (auth)

**18268** GENERALIZED O(4) HARMONICS AND BETHE–SALPETER EQUATION FOR SPINOR–SPINOR PARTICLE SYSTEM. Seto, Kenji (Hokkaido Univ., Sapporo. Kyoto Univ.,). Progr. Theor. Phys. (Kyoto); 42: 1394-1417(Dec 1969).

The generalized O(4) harmonics which are derived from the representations of the O(4) group are applied to the analysis of the Bethe-Salpeter equation for the spinor-spinor particle system exchanging vector particles at the vanishing total four-momentum. The separation of the angular variables is made by introducing the helicity amplitudes which have definite transformation properties under the O(4) group. After carrying out angular integrations, a system of one-dimensional equations is obtained which contains Goldstein's equation for the representation of M = 0 and Goldstein's equation and Kummer's one for the representation of M = ±1, where M denotes the four-dimensional helicity quantum number. All the equations belonging to M = ±1 are analytically solved in the case of massless particles exchange. On discussing the normalization properties of the solutions of Kummer's equation, it is found that the sign of norm is $\pm(-)^{n-l}$, where the double sign (±) depends on the type of combination of M = +1 and −1 amplitudes, and n and l stand for the four-dimensional and three-dimensional angular momentum numbers, respectively. The properties of the amplitude under space inversion are also discussed. (auth)

**18269** NOTE ON THE SELF-ENERGY IN QUANTUM FIELD THEORY. Imamura, Tadashi; Okajima, Kazuo; Sunakawa, Sigenobu (Osaka Univ.). Progr. Theor. Phys. (Kyoto); 42: 1468-74(Dec 1969).

The self-energies of the interacting bose fields are calculated on the basis of a new method which has been applied to evaluation of the excitation energy in liquid He II, and convergent results are obtained without introducing any ad hoc cutoff parameter. (auth)

**18270** MACROSCOPIC CAUSALITY–VIOLATION EFFECTS IN THE LEE AND WICK THEORY WITH INDEFINITE METRIC. Geshkenbein, B. V.; Terent'ev, M. V. JETP Lett. (USSR) (Engl. Transl.); 10: 312-13(20 Nov 1969).

Translated from Zh. Eksp. Teor. Fiz. Pis'ma Redaktsiyu; 10: 485-7(20 Nov 1969).

A previous field theoretic formulation including states with an indefinite metric is studied. It is noted that such unusual states must appear as a complex S-matrix poles on a physical sheet. It is shown that the existence of such poles at high energies should lead in principle to a violation of macroscopic causality. (J.F.P.)

**18271** CANONICAL GAUGE- AND LORENTZ-INVARIANT QUANTIZATION OF THE YANG–MILLS FIELD. Loos, Hendricus G. (Douglas Advanced Research Labs., Huntington Beach, Calif. Univ. of California, Riverside). Phys. Rev.; 188: 2342-53(25 Dec 1969).

The Yang-Mills field, interacting with itself but not with other fields, is quantized using canonical equal-time commutation relations that do not involve the time component of the Yang-Mills potentials or the conjugate operator. Instead of decomposing the field into physical components and gauge variables, all three spatial components of the Yang-Mills potentials are retained. This keeps the equal-time commutators simple and provides, in the Schrödinger representation, a simple solution of the problem of constraints: "Good" states, i.e., states satisfying all constraints, are represented by gauge-invariant functionals of the spatial Yang-Mills potentials. A finite scalar product for good states is given as a functional integral over a "tube" in configuration space, i.e., the space of the spatial Yang-Mills potentials over all of three-dimensional space. This tube is constructed in a certain manner around a manifold $\Xi$ of representatives for the gauge-invariant manifolds. It is shown that this scalar product does not depend on the choice of $\Xi$. For the purpose of proving Lorentz and gauge invariance of the theory, a modified Hamiltonian is considered which does not give rise to any constraints by itself, and which results in field equations which reduce to the Yang-Mills equations when applied to good states. The conventional primary and secondary constraints show up as conditions selecting the subspace of good states. Gauge invariance is proven for the complete theory, applied to good states. Lorentz invariance is proven for the equal-time commutation relations, using the method of Heisenberg and Pauli, for the conditions selecting the subspace of good states, and for the equations of motion applied to good states. Lorentz invariance of the scalar product of good states is shown by proving self-adjointness of the energy-momentum density operators, relative to the scalar product. The self-adjointness of these operators is assured by the particular construction of the tube in configuration space, over which the functional integral is taken. One may take the limit of the scalar product, letting the tube thickness go to zero, and arrive at a functional integral over $\Xi$. (auth)

**18272** 2 — n PRODUCTION PROCESSES AND THE MULTI-REGGE MODEL. Campbell, D. K. (Cambridge Univ., Eng.). Phys. Rev.; 188: 2471-85(25 Dec 1969).

Within the framework of Gribov's asymptotic Feynman-diagram approach, general production processes are considered. The multi-

Regge model (MRM) is derived, and the assumptions required in the the derivation are analyzed and justified. Classes of Feynman diagrams expected to contribute Regge-cut effects to the full production amplitude are studied. The anticipated cut behavior is established. The asymptotic limit is found to depend not only on the Reggeon "masses," but also on $\eta_i$; the additional invariants required to specify the full amplitude. The relevance of these results for multi-Regge bootstraps is discussed. (auth)

**18273** NONEXISTENCE OF ANOMALOUS COMMUTATORS IN SPINOR ELECTRODYNAMICS. Hagen, C. R. (Univ. of Rochester, N. Y.). Phys. Rev.; 188: 2416-22(25 Dec 1969).

An attempt is made to infer the existence of so-called anomalous terms in the divergence of the axial-vector current from an action-principle approach. However, the presence of the spatial vector $\epsilon$ which is used to write the axial-vector current as the limit of a gauge-invariant nonlocal operator is found to preclude the possibility of successfully carrying out such a program. It is demonstrated that this failure is only one of several field-theoretical paradoxes which arise from the use of the $\epsilon$ limiting procedure. One is thereby led to the conclusion that the definition of current operators in terms of a limit can give consistent results only in a theory which is finite or one which is made finite by a regularization technique. The effect of such considerations is shown to imply that the Schwinger–Adler result for the axial-vector divergence is to be taken as a relation between matrix elements rather than one between field operators. Of more practical concern is the fact that this serves to resolve a discrepancy which has existed between several calculations of the commutators of $j_0^5$ with the electric charge density. (auth)

**18274** EQUAL-TIME COMMUTATORS AND EQUATIONS OF MOTION FOR CURRENT DENSITIES IN A RENORMALIZABLE FIELD-THEORY MODEL. Tung, Wu-ki (Inst. for Advanced Study, Princeton, N. J.). Phys. Rev.; 188: 2404-15(25 Dec 1969).

The equal-time commutators of current densities are studied in a renormalizable field theory. From a careful study of the equations of motion for current densities and products of current densities, a relation between the full commutators and the naive commutators is derived. The difference between the two is related to the well-known seagull terms associated with time-ordered products of currents and to anomalies in the equations of motion for current densities. Previous second-order perturbation calculations on specific matrix elements are shown to be special cases of this general result. (auth)

**18275** VECTOR CURRENTS AND CURRENT ALGEBRA. II. AN N-POINT BETA-FUNCTION MODEL. Brower, Richard C.; Weis, J. H. (Univ. of California, Berkeley). Phys. Rev.; 188: 2495-2507(25 Dec 1969).

A simple N-point beta-function model (generalized Veneziano model) of the hadron bootstrap is assumed, and the properties of vector currents consistent with it are investigated. It is found that this hadron bootstrap admits conserved vector currents satisfying the Gell-Mann current algebra in a first approximation which assumes single vector-meson poles in the form factors and requires factorization only at resonances on leading Regge trajectories. It is believed that the techniques employed in this simplified model will be useful in constructing current amplitudes in more general dual zero-width models. In addition, a model for a Pomeranchon contribution which does not fall off at large $q^2$ is proposed. Throughout amplitudes for one or two vector currents and an arbitrary number N of spinless hadrons are treated. (auth)

**18276** BETHE–SALPETER APPROACH TO THE MULTI-REGGE BOOTSTRAP. Ball, James S.; Marchesini, G. (Univ. of Utah, Salt Lake City). Phys. Rev.; 188: 2209-15(25 Dec 1969).

A Bethe-Salpeter model is proposed which sums graphs that are very similar to those summed in the work of Chew, Goldberger, and Low. This model yields considerably simpler equations and allows the analytic continuation of the amplitude into the angular momentum plane. This model is used to perform the boostrap calculation for several input trajectories, including the $\rho$ and the Pomeranchuk trajectory. When linear trajectories are assumed, self-consistent values of the intercept at $t = 0$ are obtained that are in the neighborhood of 0.6. The off-shell Bethe-Salpeter wave function is bootstrapped as well as the residue of the pole at $t = 0$. (auth)

**18277** FASTER-THAN-LIGHT INERTIAL FRAMES AND TACHYONS. Parker, Leonard (Univ. of Wisconsin, Milwaukee). Phys. Rev.; 188: 2287-92(25 Dec 1969).

By means of a mathematical transformation, a set of reference frames, called superluminal inertial frames, is introduced relative to which tachyons in one spatial dimension behave as ordinary particles. One-dimensional processes involving tachyons and photons can be analyzed in the new frames, and the results transformed to the subluminal frames. The mathematical symmetry or duality between subluminal and superluminal frames and particles suggests an extension of the principle of relativity, according to which the totality of physical laws has the same form relative to both subluminal and superluminal frames. One possible consequence of this extended principle of relativity is that charged tachyons might have properties similar to those of magnetic monopoles. Another consequence is that the cross section for the backward scattering of photons by photons should be twice as great as is predicted without taking into account tachyons. The relevance of these results to our three-dimensional world is questionable because it does not appear to be possible to extend the one-dimensional theory to three dimensions. Photon-photon scattering experiments in vacuum can reveal unambiguously whether or not the predictions have physical relevance. (auth)

**18278** HOW TO BUILD PHENOMENOLOGICAL LAGRANGIANS. Coleman, Sidney (Harvard Univ., Cambridge, Mass.). pp 649-57 of Theory and Phenomenology in Particle Physics. Part B. /Zichichi, A. (ed.). New York; Academic Press Inc. (1969).

The explicit construction of the phenomenological Lagrangian is briefly explained. Field transformation laws, invariant Lagrangians, and symmetry-breaking Lagrangians are considered. (J.F.P.)

**18279** TRANSPOSITION-INVARIANT SYMMETRY BREAKING IN NONLINEAR QUANTUM FIELD THEORY. Okolowski, John Anthony. Philadelphia; Drexel Inst. of Tech. (1969). 95p.

Thesis.

It is shown that the quantum theory of the neutral scalar free field admits exact solutions for the vacuum, one-particle, and two-particle stationary states, which are also obtained by using the Rayleigh–Ritz procedure for functionalities. This method is then applied to determine conditions for the existence of approximate vacuum, one-particle, and two-particle stationary states for a theory featuring real scalar fields coupled by a generic gauge invariant non-linear interaction term and a transposition-invariant gauge symmetry breaking term. It is found that theories for which the interaction energy density divided by the sum of the squares of the fields is uniformly bounded for all values of the fields admit acceptable vacuum, one-particle, and two-particle stationary states. Furthermore, in such theories there is no interaction between two field quanta for the two-particle stationary states, that is, the S-matrix equals the identity operator. For theories such that the interaction energy density divided by the sum of the squares of the fields is not uniformly bounded for all values of the fields, we find acceptable vacuum, one-particle, and two-particle stationary states. Such theories give rise to a $\delta$-function interaction between two field quanta for the two-particle stationary state, and the exclusively S-wave total scattering cross section is calculated. Renormalization as well as bound stationary states are also discussed. (Diss. Abstr.)

**18280** REDUCTION OF THE BETHE–SALPETER EQUATION TO COUPLED INTEGRAL EQUATIONS IN ONE VARIABLE. Greenman, J. W. (Univ. of Essex, Colchester, Eng.). Nuovo Cim.; 65B: 174-80(11 Feb 1970).

By supposing a given spectral form for the solution, the Bethe–Salpeter equation is reduced to two coupled integral Fredholm equations in one variable. The kernel of the reduced integral operator is expressed as a well-defined power series which defines a natural approximative procedure for numerical solution. (auth)

**18281** DESCRIPTION OF COULOMB COVARIANCE IN QUANTUM ELECTRODYNAMICS. Wuelfing, Arnd (Univ., Goettingen, Ger.). Z. Naturforsch., 24a: 1151-60(July 1969). (In German).

The covariance of scattering theory in the formulations of quantum electrodynamics by Gupta and Bleuler, by Valatin, and in the formulation with Coulomb gauge is reinvestigated. The effect of gauge transformations and the effect of time disordering, both generally connected with a Lorentz transformation, compensate each other. For the potential in the Gupta–Bleuler formulation there exist two different generators of Lorentz transformations. (auth)

**18282** RENORMALIZATION OF ENERGY FOR A SYSTEM OF PARTICLES. Grigor'ev, V. I.; Muzylev, E. L. Vestn. Mosk. Univ., Ser. III. Fiz. Astron., No. 4, 32-5(July-Aug. 1969). (In Russian).

A system of N nonrelativistic particles interacting with a quantized scalar field is chosen (thus pair production is excluded, and the number of particles remains constant). The exchange of quanta between the nth and kth particles enters into a general picture of

the system interaction. The total field energy of the system is broken down into particular energy of the particle itself and into the interaction energy of the particles with each other. As a condition of energy renormalization an intermediate step is introduced where the total particular energy of the system is divided into N terms, each of which $\Delta E_n$ determines the part which passes to the fraction of the nth particle. Thus $\Delta E_n$ is determined both by the self-action of the nth particle and also by the action of the remaining particles of the system on that particular particle. It is shown that it is possible to exclude the sum of these contributions from the S-matrix. (TTT)

**18283** CONSTRUCTION OF QUANTUM FIELD THEORY THROUGH METRICS IN FUNCTIONAL SPACES. Vilenchik, L. Z. Vestn. Leningrad. Univ., Fiz., Khim.; No. 10, 52-60(May 1969). (In Russian).

Wightman functional and the representation of commutation relations which specify a quantum field theory is shown to be determined by the metric $\mu$ in the space dual to the nuclear space $\Phi'$ quasi-invariant under translations in $\Phi'$ and transformations of the Poincare's group. (auth)

**18284** POSSIBLE DIFFERENCE IN HEISENBERG AND SCHROEDINGER REPRESENTATIONS IN QUANTUM FIELD THEORY. Grib, A. A. Vestn. Leningrad. Univ., Fiz., Khim.; No. 10, 61-5(May 1969). (In Russian).

An example of the quantum field theory which can be described in Heisenberg representation but has no Schroedinger representation is given by analogy with the infinite degeneration of vacua in the theory of superconductivity. (auth)

### *Gravitation and General Relativity*

*Refer also to abstracts 17606, 18127, and 18152.*

**18285** NONLINEAR CHARACTER OF GRAVITY WAVES. Carstoiu, John (International Consultant Scientists Corp., Brookline, Mass.). Compt. Rend., Ser. A; 269: 826-8(29 Oct 1969). (In French).

In the discussion of the nonlinear character of gravitational waves the energy density in the field containing terms due to the Newton field and also terms due to a gravitational vortex is considered. This energy density results in a new mass density and consequently an additional negative term leading to a nonlinear equation for the propagation of gravity. Added to this is an electromagnetic energy representing a positive-mass density. Thus there is a simple connection between electromagnetism and gravitation. (J.F.P.)

**18286** THE LORENTZ PRINCIPLE AND THE GENERAL THEORY OF RELATIVITY. PART VI. Janossy, L.; Werner, A. (Central Research Inst. of Physics, Budapest). Acta Phys. Acad. Sci. Hung.; 26: 353-69(1969).

Previous work dealing with the Lorentz principle applied to general relativity notation which is particularly useful to reflect some physical ideas was introduced step by step. A summary is given of this notation and the involved technique. The formalism is freed of a number of minor inconsistencies to be found previously, and it is shown how with the help of this formalism simple expressions can be derived — among others — for the Christoffel symbols and the Riemann–Christoffel tensor. (auth)

**18287** ELECTRODYNAMICS IN THE GENERAL THEORY OF RELATIVITY. Dozmorov, I. M. (Moscow Inst. of Tech.). Izv. Vyssh. Ucheb. Zaved., Fiz.; No. 10, 83-7(1969). (In Russian).

Conditions denoting the momentum-energy tensor in an electromagnetic field (i.e., in a pure radiation field) in the general theory of relativity were formulated within the limits of Newman–Penrose formalism. It is shown that in the case in which the space permits the existence of a normal geodesic congruence (which is equivalent to the existence of wave fronts) the zero electromagnetic field can be of only two types. The symptotic behavior of one of these fields was studied. (R.V.J.)

**18288** GRAVITATIONAL RESONANT DETECTOR WITH TWO DEGREES OF FREEDOM. Lavrent'ev, G. Ya. JETP Lett. (USSR) (Engl. Transl.); 10: 318-21(20 Nov 1969).

Translated from Zh. Eksp. Teor. Fiz. Pis'ma Redaktsiyu; 10: 495-9(20 Nov 1969).

A mechanical amplifier of resonance oscillations with two degrees of freedom is shown to increase the sensitivity of resonance detectors for gravitational waves. The design of this detector is given, and its performance is calculated. (J.F.P.)

**18289** TWO-COMPONENT NEUTRINO FIELD IN GENERAL RELATIVITY. Griffiths, J. B.; Newing, R. A. (University Coll. of North Wales, Bangor). J. Phys., A (London); 3: 136-48 (Mar 1970).

The spinor equations for two-component neutrinos in Riemannian space–time are shown to be equivalent to tensor equations analogous to those for an electromagnetic field with a complex current density vector. The structure of the energy–momentum tensor for neutrinos is more complicated than for the Maxwell field, and in constructing exact solutions of the combined neutrino–gravitational equations it has been found necessary to build up the energy–momentum tensor directly from spinor quantities. Exact solutions for pure radiation fields are obtained in the case of conformally flat and cylindrically symmetric space–times, and also for a non-diagonal radiation metric. It is shown that there are no spherically symmetric radiation solutions for the type of neutrino field considered. (auth) (UK)

**18290** KILMISTER'S ALTERNATIVE FIELD EQUATIONS IN GENERAL RELATIVITY: STATIC SPHERICALLY SYMMETRIC SOLUTIONS. Tupper, B. O. J.; Phillips, G. W. (Univ. of Exeter, Eng.). J. Phys., A (London); 3: 149-60(Mar 1970).

A method of solving the alternative field equations in general relativity proposed by Kilmister (1967) is discussed and solutions are found for the case of static spherically symmetric space–times. (auth) (UK)

**18291** GRAVITATIONAL FIELD AND THE TYPE OF MATTER. Misra, R. M. (Univ. of Gorakhpur, India). Proc. Nat. Inst. Sci. India, Part A; 35: 590-5(Jul 1969).

A classification of the energy-momentum tensor is given. It is shown that for a given type of gravitational field the algebraic structure of the energy-momentum tensor may be any one of the three types discussed or vice versa. In this manner there are nine physical states possible in general relativity. (auth)

## Scattering Theory

*Refer also to abstracts 18152, 18183, and 18280.*

**18292** (ITF–69–80) ANTICLASSICAL APPROXIMATION. Kolkunov, V. A.; Rostokin, V. I. (Akademiya Nauk Ukrainskoi SSR, Kiev. Institut Teoreticheskoi Fiziki). 1969. 19p. (CONF-691035–3). Dep. CFSTI (U. S. Sales Only).

From Conference on High Energy Physics and Theory of Elementary Particles, Kiev, USSR.

The expansion of the S-matrix of the Schrodinger one-dimensional equation results in a series with diverging integrals at large parameter of quasiclassics (anticlassical approximation). The reason for the appearance of the latter is the transition of the matrix elements phases to infinity. To calculate the finite values of the matrix elements moduli squares a special technique was worked out on the basis of which a series of anticlassical expansion was obtained. The formula is applicable to strongly varied potentials and, in addition to transmission coefficient, gives also the position of the first bound level. (auth)

**18293** (UCRL–19437) MULTIPERIPHERAL DYNAMICS. Chew, Geoffrey F. (California Univ., Berkeley. Lawrence Radiation Lab.). Dec 1969. Contract W-7405-eng-48. 23p. (CONF-691202–2). Dep. CFSTI.

From Regge-Pole Conference, Irvine, Calif.

The relation of multiperipheralism with Regge poles is discussed. Included in this discussion are the multi-Regge-pole model, generation of Regge poles and cuts, and several other models and some previous results. (J.F.P.)

**18294** CONNECTION BETWEEN TOLLER AND FROISSART–GRIBOV SIGNATURED AMPLITUDES. Olive, David (Cambridge Univ., Eng.). Nucl. Phys.; B15: 617-27(1970).

Formulas are derived relating the Toller signatured O(2,1) amplitude to the conventional Froissart–Gribov amplitude and vice versa. This suggests that the amplitudes have equivalent dynamical content. Only equal mass spinless particles are considered; only rigorous analyticity domains and not necessarily the Mandelstam representation are needed. A vital ingredient of the work is the hermitian analyticity property. (auth)

**18295** GENERAL CONTINUOUS-PARAMETER SUM RULES. Garcia, A.; Masperi, L. (CNEA, Bariloche, Argentina). Nucl. Phys.; B15: 560-70(1970).

A class of general finite-energy sum rules not necessarily derived from analyticity and crossing property of the amplitude is discussed. An example is given of a sum rule which has over the continuous-moment sum rules the advantages of a more equilibrated participation of low-energy data and a better separation of two nearby Regge-pole contributions. (auth)

**18296** CALCULATING PARTIAL WAVE AMPLITUDES ON THE LEFT-HAND CUT. Petersen, J. Lyng (NORDITA, Copenhagen). Nucl. Phys.; B15: 549-59(1970).

A method is proposed which makes it possible in certain cases to calculate the value of a partial wave amplitude even to those parts of the left-hand cut where standard methods involving crossed-channel partial wave expansions fail for convergence reasons. Certain Regge information about the asymptotic behavior in the crossed channels is required. For the Veneziano model the method becomes a convenient mathematical device by which the asymptotic behavior of partial wave amplitudes may be studied. (auth)

**18297** FACTORIZATION AND CYCLIC STRUCTURE IN THE GENERALIZED VENEZIANO MODEL. Montvay, I. (Eoetvoes Univ., Budapest). Nucl. Phys.; B15: 451-60(1970).

In the generalized Veneziano model the particles of negative signature on the leading trajectory cancel as a consequence of the cyclic structure of the amplitude. It is shown that the first-daughter trajectory is non-degenerate for the same reasons. The cyclic structure is relevant also in connection with the factorization, but it turns out that the amplitudes with one excited particle also factorize in all permuted positions. A "direct inspection" proof of Fubini–Veneziano–Ward (FVW) like identities is also included. (auth)

**18298** THREE-PARTICLE PRODUCTION AMPLITUDE AT HIGH ENERGIES AND LARGE MOMENTUM TRANSFERS. Ansel'm, A. A.; Lipatov, L. N.; Winbow, G. A. (Ioffe Inst. of Physics and Tech., Leningrad). JETP Lett. (USSR) (Engl. Transl.); 10: 321-4(20 Nov 1969).

Translated from Zh. Eksp. Teor. Fiz. Pis'ma Redaktsiyu; 10: 499-504(20 Nov 1969).

A method, similar to that previously used for the asymptotic amplitude of elastic scattering, is used to obtain an expression for the asymptotic amplitudes of three-particle production at high energies and large momentum transfers. Restriction is made to the conditions that both pair energies are assumed to be large but smaller than the total energy. (J.F.P.)

**18299** 1-PLANE AND KHURI-PLANE SINGULARITIES IN THE VENEZIANO MODEL. Joshi, G. C.; Martin, A. W. (Rutgers–The State Univ., New Brunswick, N. J.). Phys. Rev.; 188: 2354-61(25 Dec 1969).

The singularity structure of the Veneziano model in the angular momentum and Khuri planes is discussed. The continued partial-wave amplitude is shown to have an infinite number of Regge poles, spaced by integers, together with an infinite number of fixed poles at wrong-signature nonsense points in the l plane. The residues of both the moving and fixed poles are calculated, and consequences of their structure are discussed. In the Khuri plane, the Veneziano model is shown to be characterized by an infinite number of moving poles, but there are no fixed poles. The residues of the moving poles are presented. (auth)

**18300** DUALITY SERIES FOR THE FIVE-POINT FUNCTION. Green, M. B. (Cavendish Lab., Cambridge, Eng.). Phys. Rev.; 188: 2223-34(25 Dec 1969).

The Feynman-like series proposed by Kikkawa, Sakita, and Virasoro, and based on duality, is considered for the planar diagrams of the five-point function. The "Born" term for this series is the Bardakci-Ruegg amplitude. It is found, by summing the series in the appropriate limit, that the amplitude has double-Regge behavior with the same coupling function as the Born term. Each output Regge trajectory is, however, modified by a correction term identical to that obtained for the four-point function and containing the correct elastic threshold. It is indicated how this correction term arises by requiring, in analogy with perturbation theory, that the Born term of the four-point function (the Veneziano amplitude) satisfies elastic unitarity. (auth)

**18301** REGGE CUTS FROM OFF-MASS-SHELL AND ON-MASS-SHELL NONPLANAR FEYNMAN-LIKE DUALITY DIAGRAMS. Rivers, R. J.; Scanio, J. J. G. (Univ. of Chicago). Phys. Rev.; 188: 2170-6(25 Dec 1969).

In a theory of Feynman-like diagrams compatible with duality, the Regge cut given by the simplest nonplanar diagrams (the unrenormalized two-Reggeon cut) is compared with the Regge cut obtained from the same diagrams in the double-scattering formalism in which the intermediate two-body state is put on one or several of its mass shells. The cut spectral functions are shown to be simply related at the branch point, but the different ways of incorporating the signature factors in the two methods give rise to zeros in the leasing cut amplitudes at different places. The predictions of a double-scattering Regge cut are thus likely to be qualitatively similar but quantitatively different from those of the Feynman-like Regge cut. (auth)

**18302** GENERALIZED INTERFERENCE MODEL. Vickson, Raymond G. (Univ. of British Columbia, Vancouver). Phys. Rev.; 188: 2154-8(25 Dec 1969).

A crossing-symmetric Regge-pole model of the generalized interference type is discussed. The model consists of a sum of infinitely many Regge poles in each channel, corresponding to a leading Regge trajectory and its parallel daughters. All the usual requirements are satisfied by the Regge residues, and nonlinear trajections can be introduced without difficulty. At the expense of a loss of physical interpretation, the double-counting problem can be eliminated by identifying the Schmid loops with the direct-channel resonances. (auth)

**18303** PERSISTENCE OF THE CASTILLEJO–DALITZ–DYSON AMBIGUITY IN RELATIVISTIC CROSSING-SYMMETRIC AMPLITUDES. Atkinson, D. (Argonne National Lab., Ill.); Warnock, Robert Lee. Phys. Rev.; 188: 2098-2111(25 Dec 1969).

The relativistic equations expressing analyticity, crossing, and unitarity are analyzed without approximations. An infinite family of solutions is constructed, corresponding to a Castillejo-Dalitz-Dyson (CDD) ambiguity in the s-wave. This ambiguity is in addition to the one resulting from arbitrary inelastic functions. The amplitudes constructed have nonvanishing single spectral functions, and this implies that a Kronecker $\delta$ is present in the angular-momentum plane. This relation between CDD poles and the Kronecker $\delta$ is proved only within a certain limited range of the coupling strength. A computational program for reaching the interesting domain of large couplings is outlined. In the latter domain it is not expected that all CDD poles entail Kronecker $\delta$'s in the l plane. (auth)

**18304** QUASI-UNITARY THREE-PARTICLE APPROXIMATIONS. Kowalski, K. L. (Univ. of Leuven, Belgium). Phys. Rev.; 188: 2235-40(25 Dec 1969).

The three-particle discontinuity equations are expressed in forms convenient for the study of unitarity violations. As an application, the constraints on the two-particle transition operators imposed by requiring consistency with three-particle unitarity are deduced. This provides a framework for some recent proposals for generating approximate, finite-rank, two-particle transition operators which do not satisfy off-shell unitarity. Also, the general features of some quasi-unitarity impulse approximations are discussed in a unified fashion in order to clarify the conditions for their validity as well as for higher-order quasiunitary approximations. (auth)

**18305** RELATIONS BETWEEN CROSSING-SYMMETRIC PROCESSES. Paschos, E. A. (Stanford Univ., Calif.). Phys. Rev.; 188: 2281-3(25 Dec 1969).

Relations between processes related by crossing are proposed as a test of (i) exchange degeneracy and (ii) dominance by trajectories of the same signature. Various possible experiments are discussed. (auth)

**18306** MODEL FOR INDEFINITELY RISING REGGE TRAJECTORIES. Trivedi, U. (California Inst. of Tech., Pasadena). Phys. Rev.; 188: 2241-53(25 Dec 1969).

The model for indefinitely rising Regge trajectories is based on the 1-excitation scheme. It has been suggested that the effective strength of forces due to Regge-trajectory exchanges increases with energy in order to overcome the centrifugal repulsion. The output Regge trajectory is thus pulled up with energy. The suggested energy increase is simulated in a simple manner by considering a Yukawa potential with an energy-dependent coupling strength. It is found therein that the output trajectory must grow at least as fast as $\sqrt{s}$. Furthermore, accompanying the leading trajectory there occurs an infinite set of trajectories associated with higher radial quantum numbers. Trajectories characterized by finite radial quantum numbers are "parallel" to the leading trajectory for large s. The various resonances occur in a well-specified pattern. This pattern has been compared with the non-strange baryon spectrum and is compatible with it. The behavior of $\mathrm{Im}\alpha$ and some multichannel effects on $\mathrm{Re}\alpha$ are also discussed. (auth)

**18307** KINEMATIC SINGULARITIES OF THE BALL–CHEW–PIGNOTTI MULTIPARTICLE AMPLITUDES. Svensson, Bengt E. Y. (Univ. of California, Berkeley). Phys. Rev.; 188: 2254-63(25 Dec 1969).

For multiparticle reactions involving massive particles of any spin, the amplitudes introduced by Bali, Chew, and Pignotti (BCP) are considered as functions of the scalar products between four-momenta. A method previously used by Trueman for 2-to-2 particle reactions and by this author for multiparticle helicity amplitudes is used to classify and explicitly extract the kinematic singularities of the BCP amplitudes. This method concentrates on the Lorentz-group parameters that define the state vectors in terms of which the amplitudes are constructed. The basic as-

sumption is that the kinematic singularities of the amplitudes are due solely to the singular behavior of these group parameters on certain surfaces, given by the vanishing of particular Gram determinants, in the space of the invariant variables. The kinematic singularities take a form which seems suitable for analyzing kinematic constraints in a factorizable multiperipheral model. (auth)

**18308** RESONANCE POLES AND RESONANCE MULTIPOLES. Coleman, Sidney (Harvard Univ., Cambridge, Mass.). pp 659-83 of Theory and Phenomenology in Particle Physics. Part B. /Zichichi, A. (ed.). New York; Academic Press Inc. (1969).

The discussion of resonance poles and multipoles is based on the analytic properties of the partial-wave S-matrix. Two-body scattering either nonrelativistic potential or full relativistic scattering is considered. The analyticity of the S-matrix through the cut and into the second sheet, resonances in single-channel scattering, a model of resonance production, and resonances in multichannel scattering are covered. (J.F.P.)

**18309** ANALYTIC PROPERTIES OF FEYNMAN INTEGRALS. Regge, T. (Inst. for Advanced Study, Princeton, N. J.). pp 723-45 of Theory and Phenomenology in Particle Physics. Part B. /Zichichi, A. (ed.). New York; Academic Press Inc. (1969).

Previous results on the relativistic Feynman amplitudes are elucidated and used in relation to the fundamental Poincaré group. This results in a complete description of the Riemann sheet structure of a few relativistic Feynman amplitudes. (J.F.P.)

**18310** TWO-DIMENSIONAL EXPANSIONS OF RELATIVISTIC AMPLITUDES IN THE MANDELSTAM TRIANGLE AND CROSSING SYMMETRIC REACTIONS. Winternitz, P. (Rutherford High Energy Lab., Chilton, Eng.). Czech. J. Phys.; 19: 1589-1601(1969).

Two-variable expansions of scattering amplitudes based on the O(3,1) group are extended into the decay region of the Mandelstam plane and compared with expansions based on an SU(3) group. The O(4) partial wave crossing matrices are calculated and the problem of imposing crossing symmetry is discussed. (auth)

**18311** MODIFIED DISPERSION RELATIONS AND SUM RULES. Fischer, J. (Inst. of Physics, Prague); Pisut, J.; Presnajder, P.; Sebesta, J. Czech. J. Phys.; 19: 1486-99 (1969).

A systematic treatment of modifications to the usual form of dispersion relations and sum rules is given. The treatment is based on the fact that if a function g(z) has analyticity properties analogous to those of a scattering amplitude f(z), the usual dispersion relation for the product f(z) g(z) holds. After having described the general form of the "weight function" g(z) cases when g(z) is large in a pre-chosen region and small elsewhere are emphasized. Weight functions of this type are useful in practical applications where a weight function g(z) may enhance a contribution of regions where accurate data are available and suppress those of regions with inaccurate or lacking data. (auth)

**18312** THE $N_l(s,r)/D_l(s,r)$ APPROACH AND THE STANDARD EQUATIONS OF THE INVERSE SCATTERING PROBLEM. Weiss, J. (Technical Univ., Bratislava). Czech. J. Phys.; 19: 1578-88(1969).

In the nonrelativistic case generating only the short-range class of potentials the fact is explained that the Marchenko equations of the inverse problem formalism are a reduced form of the generalized N/D equations (the N/D equations extended off the mass shell [1]). (auth)

## Particle Accelerators

*Refer also to abstracts 16913, 18056, 18059, 18060, 18063, 18074, and 18367.*

**18313** (BNL-14417) BETATRON FREQUENCY JUMP AT TRANSITION IN THE BROOKHAVEN AGS. Raka, E. C. (Brookhaven National Lab., Upton, N. Y.). 5 Jan 1970. 18p. Dep. CFSTI.

Recent investigations on the CERN PS have shown that by rapidly (≈1 msec) jumping the horizontal $\nu$ value (≈−.19 units at $\nu_x = 6.39$) when the transition energy is reached, the high intensity ($N \gtrsim 5 \times 10^{11}$ proton) space charge effects can be markedly reduced or eliminated. It is estimated that these effects will be ≈ 1/9 as large in the AGS for a given beam intensity than in the CERN PS. Some success at suppressing the bunch shape oscillation generated just after transition by the longitudinal space charge forces was achieved in the AGS using a feedback damping system. Also an empirically arrived at adjustment of transition parameters which in reality produces a fairly rapid $\nu$ change has been used for some time to aid in reducing the bunch shape oscillations and to minimize any rapid debunching that may occur just after transition. This method and its possible future application is described and also the available quadrupoles in the AGS which could be used for a $\nu$ jump at transition are discussed. (auth)

**18314** (CERN-69-29, pp 97-122) PLANS FOR PHYSICS WITH THE INTERSECTING STORAGE RINGS. Minten, A. ((European Organization for Nuclear Research, Geneva (Switzerland)).

The intersecting storage ring at CERN, which will allow the study of the proton–proton collisions at very high energies, is discussed. The intersecting storage rings, present knowledge of physics at ultra-high energies, and plans for experiments at the ISR are considered. (J.F.P.)

**18315** (CERN-Trans-69-30) GENERAL SCHEME OF PROTON EJECTION FOR THE IHEP ACCELERATOR. Myznikov, K. P.; Sapunov, Yu. M.; Tatarenko, V. M.; Fedotov, Yu. S.; Frolov, A. M. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Serpukhov. Institut Fiziki Vysokikh Energii). Translated by A. Golovanoff (CERN, Geneva, Switzerland), from report IFVE-SKU-68-57. 22p. (In French). Dep. CFSTI (U. S. Sales Only).

An abstract of this paper, prepared from the original language, appeared as NSA 23: 44751. (W.H.K.)

**18316** (CONF-680461-2) A SOURCE OF POLARIZED HYDROGEN IONS FOR THE TANDEM ACCELERATOR OF THE ETH. Gruebler, W.; Koenig, V.; Marmier, P. (Eidgenoessische Technische Hochschule, Zurich (Switzerland). Laboratorium fuer Kernphysik). [1968]. 10p. (In German). Dep. CFSTI (U. S. Sales Only).

From Professional Commission on Nuclear Physics, Bad Neuenahr, Germany.

A source of polarized hydrogen ions, operating on the atomic beam principle, was constructed and its design and construction are described. As preparation for the sign reversal, the cross section for the formation of negative hydrogen ions in potassium vapor was measured in the energy range from 3 to 20 keV and the polarization of a negative deuteron beam was determined as a function of the magnetic field in the sign reversal region. The patterns of the two boundary fields from the crossed magnetic and electrical fields used to rotate the polarization direction were determined. The $T(d,n)^4He$ reaction was used to test the rotation of the spin direction with satisfactory results. (J.S.R.)

**18317** (CONF-690330–, pp 81-8) THE PRESENT SITUATION AT ADONE, FROM THE POINT OF VIEW OF THE MACHINE AND OF THE EXPERIMENTS. Silvestrini, V. (Comitato Nazionale per l'Energia Nucleare, Frascati (Italy). Laboratori Nazionali di Frascati).

The present status of the Adone storage ring is described. The phase, transverse betatron, and the beam–beam instabilities are discussed, and a number of possible experiments using this storage are briefly summarized. (J.F.P.)

**18318** (KFK-tr-302) COLLECTIVE EFFECTS IN CIRCULAR ACCELERATORS. Kolomenskii, A. A.; Lebedev, A. N. (Akademiya Nauk SSSR, Moscow. Institut Fiziki). Translated by Rosemarie Corssen (Kernforschungszentrum, Karlsruhe, Ger.), from Preprint No. 176. 28p. (In German). (CONF-681029-2). Dep. CFSTI (U. S. Sales Only).

From National Particle Accelerator Conference, Moscow, USSR,

A bibliographic review is presented on the experimental studies on collective effects in circular accelerators. (58 references.) (J.S.R.)

**18319** (NP-18154) INFLUENCE OF STATISTICAL ERRORS ON THE STABILITY OF LONGITUDINAL PHASE OSCILLATIONS OF A LINEAR ACCELERATOR (FLATNESS-PROBLEM). Sauter, Elmar (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Experimentelle Kernphysik). Jul 1969. 30p. (In German). Dep. CFSTI (U. S. Sales Only).

The influence of random errors caused by construction and adjustment tolerances on the size of the stability region of longitudinal phase-oscillations are investigated analytically and numerically. The linear approximation necessary for the analytic treatment leads to the stability problem of an harmonic oscillator, whose frequency changes at random. No influence is found on that region of the phase-plane, which is used for acceleration, even for relatively large initial errors. (auth)

**18320** (ORNL-tr-2277) RADIATION YIELD OF SHIELDS FOR THE UNITED INSTITUTE OF NUCLEAR RESEARCH SYN-

CHRO-CYCLOTRON. Aleinikov, V. E.; Kimel', L. R.; (and others) (Joint Inst. for Nuclear Research, Dubna (USSR)). Translated for Oak Ridge National Lab., Tenn., from report JINR-P16-4727. 5p. Dep. CFSTI.

An abstract of this paper, prepared from the original language, appeared as NSA 24: 3800. (W.H.K.)

**18321** (ORNL-tr-2290) BIOLOGICAL SHIELDING AND TECHNIQUE OF RAPID EJECTION. Britvich, G. I.; Golovachik, V. T.; Krupnyi, G. I.; Lebedev, V. N.; Mal'kov, V. V.; Bushuev, N. I. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Serpukhov. Institut Fiziki Vysokikh Energii). Translated by R. G. Mansfield (Oak Ridge National Lab., Tenn.), from report CERN-Trans-69-13. 25p. Dep. CFSTI.

An abstract of this paper appeared previously as NSA 24: 1682. (W.H.K.)

**18322** (UCRL-18934) OPERATION OF THE POLARIZED-ION SOURCE AND AXIAL INJECTION SYSTEM FOR THE BERKELEY 88-INCH CYCLOTRON. Clark, D. J.; Luccio, A. U.; Resmini, F.; Meiner, H. (California Univ., Berkeley. Lawrence Radiation Lab.). Oct 1969. Contract W-7405-eng-48. 19p. (CONF-690921-3). Dep. CFSTI.

From International Cyclotron Conference, Oxford, England.

A polarized-ion source for protons and deuterons is now in operation at the Berkeley 88-Inch Cyclotron. The source is of the atomic beam type, using rf transitions and a strong field ionizer. It is mounted vertically above the cyclotron roof shielding. A new axial injection transport system, whose optical elements are electrostatic quadrupole triplets, brings the beam 4.5 meters down to the cyclotron median plane. A duoplasmatron source can inject unpolarized protons through a 90° bending magnet. A gridded electrostatic mirror injects the beam into the dummy dee. Electrodes inserted into the dummy dee and dee give narrow accelerating gaps to allow the beam to clear the mirror. They are designed to unplug at vacuum for easy conversion between axial injection and internal source operation. Maximum beam currents at present are up to 3 $\mu$A of polarized protons at the source, 0.05 $\mu$A accelerated in the cyclotron, and 0.02 $\mu$A external beam with a polarization of 70%. (auth)

**18323** (UCRL-Trans-1407) COHERENT ENERGY LOSSES OF A RELATIVISTIC BUNCH IN LINEAR ACCELERATING SYSTEMS. Kuznetsov, A. B.; Rubin, S. B. (Joint Inst. for Nuclear Research, Dubna (USSR)). Translated by T. Watt for Univ. of California Lawrence Radiation Lab., Livermore, from report JINR-P9-4728. 11p. Dep. CFSTI.

An abstract of this paper, prepared from the original language, appeared as NSA 24: 3799. (W.H.K.)

**18324** TRANSVERSE EXPANSION OF ION BEAM DIMENSIONS DURING PASSAGE THROUGH A PAIR OF QUADRUPOLE LENSES OF THE ML-5 TYPE. Irisbaev, K. N. (Inst. of Nuclear Physics, Tashkent). Dokl. Akad. Nauk Uzb. SSR; No. 3, 24-5(1969). (In Russian).

Transverse expansion of ion beams was determined considering a pair of quadrupole magnets as an independent focusing system. It was, also, assumed that the first quadrupole magnet is focusing in the first direction and defocusing in the second direction. Thus, the $X_1$ determined the increase of beam in the direction in which the first magnet of the pair was focusing and the $X_2$ in the direction in which it was defocusing. The magnitudes $X_1$ and $X_2$ were calculated for the quadrupole magnets of the ML-5 of the Y-150-2 cyclotron. (R.V.J.)

**18325** INJECTOR OF THE CISE 8 MeV TANDEM VAN DE GRAAFF. Cesati, A.; Cristofori, F. (CISE, Milan). Energ. Nucl. (Milan); 17: 112-17(Feb 1970).

The injector of the 8 MeV tandem Van de Graaff accelerator under construction at CISE is described. The charge exchange with cesium vapour and the focusing system are briefly discussed. (auth)

**18326** ELECTROSTATIC GENERATOR OF THE CISE 8 MeV TANDEM VAN DE GRAAFF. Caruso, E.; Milazzo, M. (CISE, Milan). Energ. Nucl. (Milan); 17: 104-11(Feb 1970).

The design of the 8 MeV tandem Van de Graaff electrostatic generator under construction at CISE is described. The tandem is of the vertical type. A maximum voltage of 4.5 MV for the generator electrode has been achieved during preliminary tests. (auth)

**18327** IMPROVED METHOD FOR CONSTRUCTING ELECTROSTATIC PRISMS. Stein, John (Rensselaer Polytechnic Inst., Troy, N. Y.). Rev. Sci. Instrum.; 41: 477(Mar 1970).

An improved technique for the fabrication of accurate, large radius-of-curvature, cylindrical electrostatic prisms is reported. The materials required are easily obtained and suitable for use in ultrahigh vacuum systems, the machining skill and equipment are minimal, and the technique is applicable to prisms of a wide range of sizes. (C.E.S.)

**18328** A QUICK METHOD FOR VERTICAL MOUNTING OF ORGANIC CHEMICALS ON GUINIER CAMERAS. Polk, Murray L. (Detroit Inst. of Tech.). Rev. Sci. Instrum.; 41: 466-7(Mar 1970).

The magneto-optical effect in a vial of $Fe_3O_4$ suspension is used to align magnetic quadrupole lenses. (C.E.S.)

**18329** STATE OF THE MAINTENANCE AND OPERATION OF THE MACHINE (30-MeV LINEAR ACCELERATOR). Kojima, Yuzo; Urasawa, Shigekazu (Tohoku Univ., Sendai). Res. Rep. Lab. Nucl. Sci., Tohoku Univ.; 1: No. 2, 159-61(Dec 1968). (In Japanese).

During the two periods of its joint use, some inconveniences were necessarily given to the users of the 30-MeV linear accelerator, due to failures and insufficient maintenance of the machine. Efforts were made, however, to fulfill the machine time specified by the ad hoc committee. Improvement and maintenance of the machine proceeded steadily to improve performance and stability of beam. Maintenance and operation of the laboratory are described for the period from September 1967 to October 1968. The maintenance included the following: installation of magnets in the accelerating tube; improvement of the injector; installation of an AVR in the steering-coil power source; repair of an electron-gun pulser; improvement of a klystron pulser; improvement of the collimator; installation of a Ti window; improvement of the master oscillator; improvement of a klystron-pulser cable; installation of a target for positrons; and installation of a TOF extension duct. The operating hours ranged from about 3 to 9 hours daily. (NSA of Japan)

**18330** ENERGY ANALYSIS OF CHARGED PARTICLES FROM A RADIO FREQUENCY ION SOURCE. 2. Torizuka, Kazuo; Iguchi, Isoo (Tokyo Gakugei Univ.). Bull. Tokyo Gakugei Univ., Ser. 4; No. 21, 8-20(Jul 1969). (In Japanese).

The energy and the spread of energy of the charged particles in the ion beam extracted from a radio-frequency ion source was investigated. The dependencies of the mean kinetic energy and the energy spread on the gas pressure, dc magnetic field, the frequency and the power of the rf oscillator and the anode voltage for the beam extraction were measured. These dependencies were explained in terms of plasma density and electron temperature of the rf plasma which were determined through various discharge parameters. (auth)(NSA of Japan)

**18331** FIRST STAGES IN THE OPERATION OF VAN DE GRAAFF ACCELERATOR AT THE NATIONAL ATOMIC ENERGY COMMISSION NUCLEAR CENTER. Fernandez, Carlos Graef. Rev. Mex. Fis. Suppl.; 18: S1-7(1969). (In Spanish).

A brief description is given of the Nuclear Center and its research facilities and programs and a historical review of its development. The Van de Graaff accelerator and its components and facilities are also briefly described. (C.E.S.)

**18332** ACCELERATOR CENTER: ARCHITECTURE, ADMINISTRATION, AND INSTALLATION. Moctezuma, Pedro; Fonseca, Carlos; Mazari, Marcos (Comision Nacional de Energia Nuclear, Mexico City). Rev. Mex. Fis. Suppl.; 18: S9-25(1969). (In Spanish).

The CNEN committed to Secretary of Public Works the projects and building (CYCSA principal contractor) of the civil works and hydraulic and electrical installations at the Nuclear Center at Salazar, Mex. The Accelerator aggregate consists of three principal buildings: the administrative with offices for the general direction of the Center, auditorium, rooms for researchers, library and quarters; the associated laboratories, with room for a computer, electronics, plate scanning, vacuum techniques, magnets, and restaurant; the accelerator itself, with control and bombarding rooms, shop, dark room, and offices. The three buildings have sanitary installations, electric sub-stations, and heating. The design took into account correct functioning architecture, and radiation protection (X rays and neutrons) with plenty of freedom for future expansions. (auth)

**18333** TANDEM VAN DE GRAAFF ACCELERATOR. TRANSPORATION, MOUNTING, AND OPERATION. Lopez, G.; Roos, R.; Dominguez, W.; (and others) (Comision Nacional de Energia Nuclear, Mexico City). Rev. Mex. Fis. Suppl.; 18: S-27-44(1969). (In Spanish).

Under HVEC expert supervision, the accelerator group undertook mounting the tandem Van de Graaff. Different aspects of this mounting included transportation, installation and alignment of accelerator and ion source, wiring, gas handling and drying system,

compressed air, gas exhaust, closed water system with cooling tower (SOP), vacuum systems and protection, and liquid-air machine. The accelerator was accepted March 15, 1968, with a proton beam of 1.5 μA at 12 MeV. Following installation, the machine was calibrated with its beam deflecting system, using the $^{27}Al(p,n)^{27}Si$ threshold. (auth)

**18334** PARTICLE DEFLECTOR AND SELECTOR SYSTEM FOR CNEN TANDEM ACCELERATOR. Alba, F. (Univ. Nacional Autonoma de Mexico, Mexico City); de la Cruz, S.; del Castillo, H.; Roos, R.; Lopez, G. Rev. Mex. Fis. Suppl.; 18: S45-69(1969). (In Spanish).

Deflecting, switching, and quadrupole magnets for the tandem Van de Graaff were built for CNEN by the Instituto de Física at UNAM. The systems' ion optics were studied using well-known matrix methods. Transistorized circuits were used for supplying and stabilizing magnets which have the following characteristics: 90° deflector with 101.5 cm radius, double focussing, deflecting up to a mass product of 108; switching magnet with 0°, ±15°, ±30° and ±45° ports, mass product 49 at 45°. Both magnets have a $1/_{10,000}$ stability. Besides focussing, the quadrupoles correct the beam direction by unbalancing the current in different coils. (auth)

**18335** CHARACTERISTICS OF NUCLEAR SPECTROMETER. Martinez B, A.; Alba, F.; Lopez, G.; Mazari, M. (Comision Nacionale de Energia Nuclear, Mexico City). Rev. Mex. Fis. Suppl.; 18: S89-99(1969). (In Spanish).

Mattauch-Elbek spectrographs are more uniform, in regard to resolution, solid angle, and magnification than Bainbridge-Buechner type instruments. In normal operation, the proposed spectrograph will admit simultaneously particles with a ratio of maximum to minimum energy of 7.1, with radius of curvature ranging from 30 to 80 cm, into a solid angle of $7.6 \times 10^{-4}$ steradian and maximum magnetic field of 15 kilogauss. Parametric equations for the focal surface, as well as general instrument optics, are included. (auth)

**18336** APPLICATION OF FIELD CONFIGURATION CURVES IN ESTIMATION AND CORRECTION OF STRAY MAGNETIC FIELDS. Mazari, M.; Terol, R.; Martinez B, A. (Comision Nacional de Energia Nuclear, Mexico City). Rev. Mex. Fis. Suppl.; 18: S101-10(1969). (In Spanish).

Hand-traced field configuration curves have been used in treating stray magnetic fields in order to estimate, modify, and correct their effects at pole edges. There are local deviations of 30% and mean deviations of less than 8%, as compared with actual measurements. (auth)

**18337** ELECTRIC AND MAGNETIC ASPECTS OF SPECTROGRAPH. Roos, R.; Murillo, G.; Lopez, G. (Comision Nacional de Energia Nuclear, Mexico City). Rev. Mex. Fis. Suppl.; 18: S111-16(1969). (In Spanish).

A magnetomotive force of 43168 Gilbert was calculated as necessary to produce a homogeneous deflecting field of 15 kilogauss, taking into account also losses due to the magnetic shielding used to reduce stray fields. The variable power supply from 25 to 500 A is similar to that of the deflecting magnets. A diagram of the N.M.R. fluxmeter using hydrogen is included. (auth)

**18338** SPECTROGRAPH AS A WIDE RANGE NUCLEAR POLARIMETER. Mazari, M.; Lopez, G.; Calvillo, J.; Mondragon, A.; Murillo, G.; Sandoval, A. (Comision Nacional de Energia Nuclear, Mexico City). Rev. Mex. Fis. Suppl.; 18: S117-27 (1969). (In Spanish).

The cyclotron property of Mattauch-Elbek spectrographs, allows keeping polarization over a broad-range of energy-separated reaction particles, by choosing 100° deflection for protons. Polarization of other types of particles may be measured separately for each group by placing the gap in the reaction plane. Estimates of the time needed to obtain double scattering spectra are presented, for cross sections as low as 0.1 mb/steradian, as well as expected errors. (auth)

**18339** DESIGN AND CONSTRUCTION OF MECHANICAL PARTS OF THE SPECTROGRAPH. Rodriguez, S.; Canseco, G.; Castro, A.; Mazari, M.; Terol, R.; Murillo, G.; Martinez B, A. (Comision Nacional de Energia Nuclear, Mexico City). Rev. Mex. Fis. Suppl.; 18: S129-38(1969). (In Spanish).

Some essential components that describe the mechanical structure of the instrument are shown. Included are the magnetic yoke, the vacuum chamber that includes the pole pieces, the photographic plate holder, and the rotating support. (auth)

**18340** CURRENT EXPERIMENTS AT THE CAMBRIDGE ELECTRON ACCELERATOR. Deutsch, Martin (Massachussets Inst. of Tech., Cambridge). pp 685-99 of Theory and Phenomenology in Particle Physics. Part B. /Zichichi, A. (ed.). New York; Academic Press Inc. (1969).

Experimental techniques at the Cambridge electron accelerator are discussed. Also some current or recently completed experiments at the CEA are briefly summarized. (J.F.P.)

**18341** ACCELERATING DEVICE. Sakamoto, Teiichi. (to Nisshin Electric Co.). Japanese Patent 1969-15479. 9 Jul 1969. Filed 6 Sep 1965.

A Cockcroft–Walton accelerator is described where the electrodes in the accelerating tube are pretreated prior to the actual operation. The pretreatment is carried out by producing a potential between the electrodes. The advantages obtained are prevention of breakage of voltage-multiplying members by reducing abnormal high-voltage. The accelerating device is composed of a voltage-multiplying mechanism consisting of multiplying stages, and the accelerating tube consisting of the corresponding accelerating electrodes. Connections between the multiplying stages and the accelerating electrodes are made in two ways, and these two connections are arranged alternately. In one way, the connection is direct; but in the other, the connection is through a switch, which connects an electrode to its own voltage multiplying stage used in the actual operation, to the next lower stage, and to the next higher stage. In the pretreatment of the accelerating electrodes, an electrode is connected to a stage next lower than its own stage, and the next lower accelerating electrode itself is connected to the same stage and voltage is applied to the whole system. This procedure is repeated also with the electrode connected to the next higher stage. (NSA of Japan)

**18342** PRODUCTION, ACCELERATION, AND UTILIZATION OF POLARIZED HELIUM-THREE IONS. Findley, David Owen. Houston, Tex.; Rice Univ. (1969). 123p.
Thesis.

A source of polarized $^3He^+$ ions has been constructed. An optical pumping technique is used to polarize the nuclear spins of the ions, which are extracted in the manner of an rf ion source of conventional design. A description of the optical pumping process in a flowing gas system is given, and the influences of the requirements of this process on the design of the ion source are discussed. The components of the ion source are described. In a nuclear double scattering experiment, a polarization of 0.05 was observed in the ion beam, with an intensity of 4 microamperes. Also, the acceleration of polarized $^3He$ ions is discussed, the emphasis being on depolarization problems of $^3He^{++}$ and $^3He^+$ ions in orbital accelerators. For $^3He^{++}$ ions, two methods for calculating the depolarization are adapted from techniques developed for polarized protons—one a rotating coordinate frame, classical approach, and the other a quantum mechanical calculation. These two methods are illustrated by an actual calculation of the depolarization during acceleration to 120 MeV of $^3He^{++}$ ions in an 88-inch, 3-sector AVF cyclotron. The two methods are criticized and the limits of their validity pointed out. For the case of $^3He^+$ ions, the frequencies of perturbing fields necessary to induce transitions among the hyperfine states of the ion are calculated from a determination of the energy eigenstates and eigenvalues. The strengths of the transitions are calculated and compared with the strength of the transition for the $^3He^{++}$ ion. It is shown that depolarization of $^3He^+$ in a cyclotron is unlikely because of the extremely high frequencies involved ($>4 \times 10^9$ Hz) and the small magnitudes of the perturbing fields at these frequencies. The requirements for adiabaticity of magnetic field direction changes are established. A discussion of electrostatic and electromagnetic methods of changing the direction of the spin polarization axis is given. Also, the uses of polarized $^3He$ ions as nuclear probes are discussed. The direction of research with polarized $^3He$ ions is suggested, along with brief descriptions of the types of experiments which might be performed once the ion source has been installed on an accelerator. Applications to elastic scattering, nuclear spectroscopy, and direct reaction studies are discussed. (Disser. Abstr.)

**18343** NEUTRON DIFFRACTION WITH THE ELECTRON LINAC AT TOHOKU UNIV. Kimura, Motoharu; Sugawara, Masumi (Tohoku Univ., Sendai). Res. Rep. Lab. Nucl. Sci., Tohoku Univ.; 1: No. 1, 55-62(1968). (In Japanese).

It is well known that with a pulsed neutron source neutron diffraction measurement is possible by the time-of-flight method. This was attempted using a 300 MeV electron linac. The primary neutron pulse, 2 to 2.5 μsec in width, was produced with ten sheets of Pb, 3 mm thick, immersed in a water bath of 10 cm × 12 cm. The thermal neutron pulse, 58 μsec in width, of intensity (0.6 to 2.8) $\times 10^9$ n/sec cm$^2$ was obtained. Flight path length was 900 + 45 cm. Two $BF^3$ counters 25 mm in diameter and 240 mm long were used as detectors. Bragg reflection from copper single crystal was shown. The machine time required was 1 hr. The Debye–Scherrer method was also attempted with Al, Cu and Fe powders, and the results are shown. With the improvement in the $^3BF$ counters and the electron linac, considerable progress

for the better resolution or the reduction in machine time can be expected. Comparison with previous neutron diffraction data by the T–O–F method was given. (NSA of Japan)

**18344** IMPROVEMENT OF NEUTRON DIFFRACTION METHOD USING ELECTRON LINAC. Kimura, Motoharu; Sugawara, Masumi (Tohoku Univ., Sendai). Res. Rep. Lab. Nucl. Sci., Tohoku Univ.; 1: No. 2, 81-104(Dec 1968). (In Japanese).

For the study of neutron diffraction by means of time-of-flight method, a Debye–Scherrer type apparatus was constructed. Diffraction patterns of Si, Al, Ni, Ca, $Fe_2O_4$, $\alpha$-$Fe_2O_3$ and MnP (all in powder) were obtained. Diffraction from Al, Ca, $Fe_2O_4$, $\alpha$-$Fe_2O_3$ and MnP was measured with the sample in a liquid nitrogen cryostat. For the diffraction angle $2\theta = 90°$, high resolution and relatively high counting rate were realized, and the diffraction pattern was comparable with that given by the IBR pulse pile (1kW) of U.S.S.R. Resolution as high as, and data accumulation rate several times higher than the Risö atomic pile (10 MW) with chopper were realized. For $2\theta = 30°$, which is appropriate to study the diffraction pattern from such planes with relatively large intervals as is observed in the case of magnetic scattering or superlattices, resolution was not as high and further improvement is possible. (NSA of Japan)

**18345** POSITRON ACCELERATION USING 30 MeV LINAC. Nakada, Yoshiaki; Saito, Teijiro (Tohoku Univ., Sendai). Res. Rep. Lab. Nucl. Sci., Tohoku Univ.; 1: No. 2, 151-8(Dec 1968). (In Japanese).

Positron acceleration was attempted using the 30 MeV linac. The 30 MeV linac has two accelerator tubes, one 1 m, the other 2 m in length. The target for positron production was placed between the two tubes, and the electron beam accelerated in the 1 m tube was impinged on it. The target was made of Ta of 1 mm in thickness. The focus coil for the positron beam was placed immediately behind the target. Positron produced in pair production were accelerated in the 2 m tube by varying the phase of the rf field. Accelerated positrons were analyzed with a magnet, and detected with an ionization chamber. Energy spectrum of positrons thus obtained is shown. For some phase of the rf field, the positron beam showed two peaks in energy. For a more retarded phase, the higher energy peak was accelerated. The effect of the focus coil was shown. Positron energy can be varied from 9 to 20 MeV. The maximum current obtained was 2 $\mu\mu$A with $\Delta P/P = 3\%$. (NSA of Japan)

**18346** VACUUM PROBLEMS OF PARTICLE ACCELERATORS AND STORAGE RINGS. Fischer, E. (CERN, Geneva). Vakuum-Tech.; 18: 94-102(May 1969). (In German).

Particle accelerators work at a residual gas pressure of about $10^{-6}$ torr. For storage rings a pressure less than $10^{-9}$ torr is needed. For experiments with colliding beams in limited sections of storage rings pressures less than $10^{-11}$ torr are required. It is shown, which essential mechanisms of perturbance determine the maximum permissible total pressures and what are the requirements on the composition of the residual gas. Almost all particle accelerators and storage rings have a vacuum chamber in the form of a long tube with pumps attached at regular intervals. A simple equation describes the pressure distribution in such a system. The decisive role of the desorption of gas from the chamber walls and other parts, as well as methods to reduce this desorption, are discussed. All recent accelerators and storage rings make use of sputter-ion pumps. A strong preference exists also for turbomolecular pumps for the preevacuation. Additionally cryopumps are used for storage rings. Flange connections on particle accelerators must resist intensive radiation. For storage rings they must also be bakeable. Metal gaskets are much preferred for both applications. The high residual radioactivity remaining after the switching off of particle accelerators calls for the development of quick coupling flanges and of such flange connections which can be opened and closed by a remotely controlled manipulator. (auth)

**18347** LOW MAGNETIC-FIELD OPTIMIZATION OF FOCUSING DEVICE IN A HELIX LINEAR ACCELERATOR. Junior, P. H.; Deitinghoff, H. (Univ., Frankfurt am Main). J. Comput. Phys.; 5: 1-12(Feb 1970).

A computer program is presented which is useful in designing optimal focusing devices for the synchronous particles in a non-periodic linear accelerator. The latter is divided into sections, each containing a helix-accelerating structure and a quadrupole doublet. The helix sections of constant length differ with respect to flight times and rf conditions. Foundations are compiled, the program is discussed and an example for focusing in a low-energy accelerator is presented. (auth)

**18348** AN ELECTRON DISCHARGE DEVICE. Colvin, Alex David; Nilssen, Ole Kristian; Turner, Allen Henry (to Ford Motor Co.). British Patent 1,179,277. 28 Jan 1970. Filed 14 Feb 1967.

Reference is made to devices having an electron window of a type which allows increased output in continuous irradiation processes. The window is of metallic construction and is provided with a support and heat sink having a thermal conductivity not below that of Al. A number of non-intersecting window-contacting metallic supports are supported by the heat sink, extending in substantially parallel relationship to each other and spaced apart at distances of less than 1 inch. The window support and heat sink are adapted to continuously absorb heat generated in the window by the action of the high energy electrons. A cooling fluid may be employed to transfer heat from the metallic supports and the latter may be provided with a peripheral support having conduits for the cooling fluid. (UK)

# PHYSICS (NUCLEAR)

## Neutron Interactions with Matter

*Refer also to abstracts 16813, 18035, 18343, and 18344.*

18349 (JUL-610-RG) A COMPARATIVE INVESTIGATION ON THE INFLUENCE OF DIFFERENT CRYSTAL MODELS ON THE SCATTERING OF THERMAL NEUTRONS IN BERYLLIUM OXIDE WITH THE HELP OF THE COMPUTER PROGRAM COLLI. Schroeder, Guenter (Kernforschungsanlage, Juelich (West Germany). Institut fuer Reaktorentwicklung). Aug 1969. 123p. (In German). Dep. CFSTI (U. S. Sales Only).

With the COLLI program developed for the calculation of the scattering matrices of polycrystalline moderators, which could contain varying atom types, the effects of the phonon spectra derived from the various crystal models on the scattering properties of the moderator beryllium oxide was systematically investigated. The integral scattering properties of the moderator BeO, the inelastic scattering cross section, the mean logarithmic energy loss, and the mean scattering cosine were described equivalently from the various phonon spectra. A comparison of the neutron flux spectra calculated with the different phonon spectra shows maximum deviations of 6% in some energy groups so that smaller deviations are given for the mean reaction rates and deviations of the order of magnitude of 1% are given for the effective multiplication constant as a function of the reaction rates. The various temperature dependencies of the scattering were also compared. The temperature behavior of the scattering law, the integral parameter of the phonon spectrum, the scattering matrix, and the integral scattering magnitudes show that for increasing temperatures the probability for inelastic neutron scattering increases, the energy changes of the scattering neutrons in the forward and backward scattering were larger, and a treatment of the scattering by the free gas model was necessary for higher energies. The effect of the atom approximation to the mean was studies by comparison with the corresponding atomic approximation to the mean phonon spectra. The calculated scattering law, the scattering matrices, and the integral scattering properties, as well as the neutron flux spectra agree well qualitatively. The comparison calculations show that the incoherent approximation for energies above 0.01 eV and the approximation of the isotropy for polycrystals of BeO as well as the atomic approximation to the mean of the weighted phonon spectra can be used in the calculation of the scattering matrices of BeO with good results. (tr-auth)

18350 ANALYSIS OF THE TRANSMISSION OF 24 keV NEUTRONS BY GOLD SPHERES USING SPIN-DEPENDENT S-WAVE STATISTICS. Semler, Thor T. (Lewis Research Center, Cleveland). Nucl. Sci. Eng.; 39: 259-63(Feb 1970).

A Monte Carlo analysis of 24-keV neutron transmission by gold spheres using spin-dependent s-wave statistics is described. (J.W.R.)

18351 DIFFUSION NEUTRON COOLING IN WATER MEDIUM WITH HOLLOW CYLINDRICAL CHANNELS. Khristov, Vasil; Ilieva, Krasimira; Damyanov, Dimit'r. Izv. Fiz. Inst. Aneb, Bulg. Akad. Nauk.; 19: 191-7(1969). (In Bulgarian).

The diffusion cooling factor of the thermal neutrons in a heterogeneous system of water and hollow cylindrical channels with a 0.5 cm radius of the channels and 1.8 cm pitch of the lattice was determined by the method of moderator poisoning with 1/v absorber. The obtained value of the factor in a heterogeneous system—47270 $cm^4\ s^{-1}$ exceeds with more than one order the respective value for a homogeneous system of pure water. The values of the diffusion coefficient ($\overline{Dv}$) and the mean absorption cross section $v\Sigma_a$ for a heterogeneous and for a control homogeneous system were also determined. The data obtained show that the absorption cross section decreases 1.3 times and the mean diffusion coefficient increases 1.5 times in water with hollow channels. The measured value of the diffusion "elongation" $L^2/L_0^2 = 1.92$ in the examined homogeneous system is well in accordance with that calculated using Birens' theory. (auth)

18352 CONCERNING A GAS OF ULTRACOLD NEUTRONS IN A TRAP. Antonov, A. V.; Isakov, A. I.; Kazarnovskii, M. V.; Solodilov, V. E. (Lebedev Inst. of Physics, Moscow). JETP Lett. (USSR) (Engl. Transl.); 10: 241-4(20 Oct 1969).

Translated from Zh. Eksp. Teor. Fiz. Pis'ma Redaktsiyu; 10: 380-5(20 Oct 1969).

The factors influencing the duration of the storage of a gas of ultracold neutrons in traps are investigated. A method for obtaining ultracold neutrons directly in a trap is proposed. (J.W.R.)

18353 NUMERICAL SOLUTION OF THE NEUTRON TRANSPORT EQUATION. Bowden, R. L.; Bullard, A. G. (Virginia Polytechnic Inst., Blacksburg). J. Nucl. Energy; 23: 655-62 (Dec 1969).

An outline of a procedure for directly solving the singular integral form of the one-speed neutron transport equation is given. The procedure is illustrated by considering the Milne problem and a one-region critical problem. Examples of numerical results obtained for these two problems are presented. (auth) (UK)

## Nuclear Properties and Reactions, A≤5

*Refer also to abstracts 18097, 18129, 18367, and 18446.*

18354 (N-69-40979) INTERACTION OF 42-MeV ALPHA PARTICLES WITH $^3$He. Vincent, John S.; Boschitz, Edmund T. (National Aeronautics and Space Administration, Cleveland, Ohio. Lewis Research Center). Nov 1969. 20p. (NASA-TN-D-5530). CFSTI.

The center-of-mass differential cross section for the elastic scattering of 42-MeV alpha particles from $^3$He was measured between 20 and 160°. Nonelastic events were integrated to estimate the total reaction cross section. Differential cross sections for $^3He(\alpha,p)^6Li$ to the ground and first excited states were measured between 20 and 160°. An optical model description of the elastic data gives a satisfactory description if the absorptive potential is radially extended beyond the real potential. The reaction cross sections are qualitatively described by the distorted-wave Born approximation theory. (auth) (STAR)

18355 NOTE ON THE CHARGE FORM FACTOR FOR THE $^4$He NUCLEUS. Bijedic, N.; Maric, Z. (Boris Kidric Inst. of Nuclear Sciences, Vinca, Yugoslovia). Lett. Nuovo Cim.; 2: 831-4(11 Dec 1969).

The charge form factor for $^4$He was calculated using a generalized Gibson wave function and both Gaussian and Irving shape functions. The calculations with the Irving shape function produced the best agreement with experiment. (J.W.R.)

18356 THE DEUTERON AND ITS MAGNETIC MOMENT. EFFECTS OF NONLOCAL NUCLEAR FORCES AND OF UNITARY TRANSFORMATIONS. Drope, E.; Lommer, Chr. (Univ., Cologne). Z. Phys.; 232: 348-55(1970).

The deuteron theory is renewed and completed for nonlocal Hamiltonians. A method to calculate deuteron wave functions is given. The formula for the current density and the magnetic dipole moment of a nonlocal potential is derived and applied to the GCT, GT and HJ potential. The effects of a unitary transformation on the deuteron data—electric quadrupole moment, magnetic dipole moment, and radius—are shown. For the numerical calculations the Ristig-Kistler transformation and the HJ potential were used. It is shown that an over-all fit cannot be reached. (auth)

## Nuclear Properties and Reactions, 6≤A≤19

*Refer also to abstracts 18066 and 18071.*

18357 (LNF-69/19) NUCLEAR RECOIL CORRECTION AND SHORT RANGE NUCLEON-NUCLEON CORRELATIONS IN ELASTIC ELECTRON SCATTERING FROM LIGHT NUCLEI. Note No. 439. Malecki, A.; Picchi, P. (Comitato Nazionale per l'Energia Nucleare, Frascati (Italy). Laboratori Nazionali di Frascati). 24 Mar 1969. 17p. Dep. CFSTI (U. S. Sales Only).

Nuclear center-of-mass motion corrections and short range nucleon-nucleon correlations in electron elastic scattering by light nuclei are calculated in the framework of the two oscillator model. The model is applied to the elastic form factors for $^6$Li, $^{12}$C, and $^{16}$O. A good fit to the $^6$Li experimental data is obtained. (J.W.R.)

18358 PROTON SPIN FLIP IN THE REACTIONS $^{12}C(p,p')^{12}C^*(4.44)$ AND $^{120}Sn(p,p')^{120}Sn^*(1.17)$. Kolata, James J. East Lansing, Mich.; Michigan State Univ. (1969). 154p. Thesis.

The spin-flip probability for protons inelastically scattered from

the first $2^+$ state in $^{12}C$ and $^{120}Sn$ was measured at incident proton energies of 26.2 and 40.0 MeV for $^{12}C$, and 30.0 MeV for $^{120}Sn$. The experimental method involved the detection of inelastically scattered protons in coincidence with de-excitation gamma radiation emitted along the normal to the scattering plane. It can be shown that this correlation is directly proportional to the spin-flip probability in the reaction. Angular distributions were obtained over an angular range of 25 to 155° in the laboratory system for the $^{12}C$ target, and from 30 to 155° for the $^{120}Sn$ target. The data display prominent backward peaks similar to previous observations at lower energies and for other nuclei. The magnitude of this peak in the spin-flip probability was about 0.30 for $^{12}C$ and 0.50 for $^{120}Sn$ and the location of its rapidly rising edge seems to be correlated with the target mass number. The total spin-flip probability is only about 0.03 for $^{12}C$ and 0.08 for $^{120}Sn$ despite the large backward peak in the angular distribution, because the inelastic cross section is largest at the forward angles where the spin-flip probability is small ($\lesssim 0.10$ for both targets). Distorted-wave calculations were performed with collective-model and microscopic-model form factors in an attempt to determine the type of information about spin-dependent nucleon-nucleon forces which can be extracted from spin-flip data. The theoretical predictions were in semi-quantitative agreement with experiment at the peak of the distribution. The most serious failure in this regard occurred for the $^{12}C$ data at 40.0 MeV where the predicted peak spin-flip probability was 0.20 compared to the measured value of about 0.30. Larger differences were observed for the forward angle data. In the case of $^{12}C$, these discrepancies were associated with the failure of the optical model for this light nucleus, and no definite conclusions could be reached regarding the spin-dependent part of the inelastic interaction. For the $^{120}Sn$ data, however, there is some evidence that the observed discrepancies are related to the spin-dependence of the inelastic interaction. If this is the case, a more adequate treatment of this interaction may significantly improve the agreement between theory and experiment. (Disser. Abstr.)

**18359** A CALCULATION OF ODD-PARITY STATES IN $^{16}O$ AND $^{40}Ca$ FROM THE NUCLEON–NUCLEON INTERACTION. Haug, P. K.; Weigel, M. (Univ., Munich). Lett. Nuovo Cim.; 2: 799-804(11 Dec 1969).

The Green's function method was used to calculate the low-lying negative parity levels of $^{16}O$ and $^{40}Ca$. A simple hard-shell Puff potential was used for the nucleon-nucleon interaction. The results are compared with experimental data. (J.W.R.)

**18360** RMS CHARGE RADII OF $^{16\,17\,18}O$ BY ELASTIC ELECTRON SCATTERING. Singhal, R. P.; Moreira, J. R.; Caplan, H. S. (Saskatchewan Accelerator Lab., Saskatoon). Phys. Rev. Lett.; 24: 73-5(12 Jan 1970).

The charge radii of $^{16,17,18}O$ were determined by elastic electron scattering using a gas target system. The result obtained is $R_{17} < R_{16} < R_{18}$. (auth)

**18361** EMISSION OF ENERGETIC HELIONS IN PROTON–NUCLEI REACTIONS AT 570 MeV. Fain, Jean (Faculte des Sciences, Clermont-Ferrand, France). J. Phys. (Paris); 30: 599-607(Aug-Sep 1969). (In French).

Interactions of 570 MeV protons with emulsion nuclei were studied. The scanning was focused on the emission of the nuclei with energy greater than 50 MeV. The results cannot be explained assuming knock-on of clusters by cascade particles. A qualitative agreement with the pick-up model is observed. (auth)

**18362** A STUDY OF THE $^{16}O$ GIANT RESONANCE REACTIONS WHICH RESULT IN EXCITED STATES IN THE RESIDUAL NUCLEI. Murray, Kenneth Malcolm Jr. Washington, D. C.; Georgetown Univ. (1969). 91p.

Thesis.

Gamma rays resulting from the decay of excited states in $^{15}O$ and $^{15}N$ were observed when these states were produced from $(\gamma,n)$ and $(\gamma,p)$ reactions on $^{16}O$. Bremsstrahlung from an electron linac was used as a source of gamma rays to produce the excited states of the A = 15 nuclei via the $^{16}O$ giant resonance. The positive parity quadruplet resulting from the above described reaction was resolved into its four separate components and the width of each component was observed. Limits on lifetimes for all of the observed transitions were determined from the Doppler-broadening of these lines. The two $5/2^+$ states at 5.240 MeV in $^{15}O$ and at 5.270 MeV in $^{15}N$ were observed to have lifetimes considerably greater than $10^{-13}$ sec. All other transitions observed appeared to have lifetimes short compared to $10^{-13}$ sec. It was also observed that the branching ratio of the 9.223 MeV level in $^{15}N$ to the $1/2^+$ state at 5.299 MeV could not be greater than 50%. A detailed theory of the line shape resulting from the Doppler effect is presented. (Disser. Abstr.)

**18363** VIOLATION OF ISOSPIN SELECTION RULES IN THE $(d,\alpha)$ REACTION AT $E_d = 7.0$ MeV. Denisov, A. E.; Kolalis, R. P.; Nemilov, Yu. A.; Sadkovskii, V. S.; Teterin, E. D. Izv. Akad. Nauk SSSR, Ser. Fiz., 33: 1376-8(Aug. 1969). (In Russian).

According to the isospin selection rule, in a $(d,\alpha)$ reaction it is not possible to excite levels of the final nucleus whose isospin is different from the isospin of the ground state of the target nucleus. Even-even target nuclei are the most readily available for experimental study of this problem, since levels with T = 1 in the final nucleus are low-lying. At present violations of the selection rules are observed in many nuclei, but at various energies of the incident deuteron. From this behavior it is not possible to explain the dependence of the magnitude of the violation on the mass number of the target nucleus. The degrees of violation of the isospin selection rule on $^{12}C$, $^{16}O$, $^{24}Mg$, $^{32}S$ and $^{40}Ca$ nuclei were determined from the relative intensity of transitions to levels with T = 1. The observed regularities can be explained on the assumption that the deuteron in the inlet channel goes over into a singlet state. (TTT)

**18364** POLARIZATION TRANSFER IN THE $^7Li(p,n)^7Be$ REACTION. Ho-Kim, Q.; Ramavataram, K. (Univ. Laval, Can.). Phys. Lett.; 31B: 5-6(5 Jan 1970).

The polarization transfer coefficients $\alpha_i$ have been calculated for the reactions $^7Li(p,n)^7Be$ and $^7Li(p,n)^7Be^*$ and found to be in good agreement with the recently reported data. (auth)

**18365** $^{12}C$ AS A NUCLEUS OF SYMMETRY (444). Hutzelmeyer, H.; Hackenbroich, H. H. (Univ., Cologne). Z. Phys.; 232: 356-62(1970).

The T = 0 spectrum of $^{12}C$ is calculated by diagonalizing a realistic 12-nucleon Hamiltonian in a space of cluster wave functions with spatial symmetry Young diagram [444]. The results give a good correspondence with the low-lying experimental levels. A good qualitative description of these levels is given by a simple model of three bosons which move translationally invariant in a harmonic oscillator; this model serves as a starting point for the calculation. (auth)

**18366** RADIATIVE WIDTH OF THE 1.56- AND 1.35-MeV LEVELS IN $^{19}F$. Walcher, Th.; Strehl, P. (Technische Hochschule, Darmstadt, Ger.). Z. Phys.; 232: 342-7(1970). (In German).

The ground state radiative widths of the 1.56-MeV ($\frac{3}{2}^+$) and the 1.35-MeV ($\frac{1}{2}^-$) levels in $^{19}F$ were determined by inelastic electron scattering. The measured cross sections have been analyzed using DWBA calculations. The results $\Gamma_\gamma^0(\frac{1}{2}^- \to \frac{1}{2}^+, E3) = (8.1 \pm 1.7) \times 10^{-10}$ eV and $\Gamma_\gamma^0(\frac{3}{2}^+ \to \frac{1}{2}^+, E2) = (1.76 \pm 0.15) \times 10^{-4}$ eV are in agreement with, but more accurate than, former measurements. (auth)

## Nuclear Properties and Reactions, $20 \leq A \leq 89$

*Refer also to abstracts 16857, 18066, 18359, 18361, and 18363.*

**18367** (COO-535-603) TECHNICAL PROGRESS REPORT [ON NUCLEAR PHYSICS], NOVEMBER 1, 1968–NOVEMBER 1, 1969. (Colorado Univ., Boulder. Dept. of Physics and Astrophysics). 1 Nov 1969. Contract AT(11-1)-535. 124p. Dep. CFSTI.

ALUMINUM-27 — helium-3 reactions (He-3, Li-6) at 40 MeV, angular distributions for, (E)
BETA SPECTROMETERS — description of on-line
BISMUTH-209 — proton elastic scattering at 23 to 30 MeV, cross sections for, (E)
CALCIUM-40 — energy levels from potassium-39 (He-3,d) reactions, spectroscopic factors for, (E)
CARBON-12 — alpha reactions ($\alpha$,p) at 28 and 37 MeV, angular distributions for, (E)
COPPER-63 — proton reactions at 26 MeV, neutron angular distributions for, (E)
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CYCLOTRONS — ion source for FFAG, design of pulsed
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— helium-3 reactions (He-3,p) at 38 MeV, angular distributions for, (E)
FLUORINE-19 — helium-3 reactions (He-3, Li-6) at 22 and 30 MeV, angular distributions for, (E)

INDIUM-113 — helium-3 reactions (He-3,d) at 38 MeV, DWBA analysis of, (E/T)
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LEAD-208 — proton elastic scattering at 23 to 30 MeV, cross sections for, (E)
MAGNETIC ANALYZERS — development of quadrupole, for nuclear reaction studies
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METHANE, FLUORO — radiation effects on labeled density of yields of fluorine-18-labeled products from neutron
NICKEL-60 — proton reactions at 26 MeV, neutron angular distributions for, (E)
— alpha reactions at 31 MeV, neutron angular distributions for, (E)
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PHOSPHORUS-29 — energy levels from silicon-28 (He-3,d) reactions, spectroscopic factors for, (E)
POTASSIUM-39 — helium-3 reactions (He-3,d) at 29 MeV, DWBA analysis of, (E/T)
SELENIUM-70 — isomeric transition in, multipolarity and L/K conversion ratio for, (E)
SILICON-28 — helium-3 reactions (He-3,d) at 40 MeV, DWRA analysis of, (E/T)
— helium-3 elastic scattering at 40 MeV, differential cross sections for, (E)
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SILICON-29 — energy levels from silicon-28 (He-3,2p) reactions, (E)
SPECTROMETERS — development of high resolution charged particle time-of-flight
TANTALUM-179 — energy levels from tungsten-179 decay, (E)
TANTALUM-181 — proton reactions (p,2n) and (p,3n) at 7.5 to 26 MeV, $\gamma$ and conversion electron spectra from, (E)
TIN-114 — energy levels from indium-113 (He-3,d) reactions, spectroscopic factors for, (E)
TITANIUM-46 — helium-3 reactions (He-3,t) at 38 MeV, triton spectra from, (E)
TUNGSTEN-179 — electron-capture decay of ground-state and isomeric, $\gamma$ singles and coincidence spectra from, (E)
TUNGSTEN-180 — energy-level transitions from tantalum-181 (p,2n) reactions, internal conversion coefficients for, (E)
X-RAY SPECTROMETERS — development of germanium crystal diffraction
YTTRIUM-89 — helium-3 reactions (He-3,t) at 38 MeV, triton spectra from, (E)
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— proton reactions (p,n$\gamma$) at 12 MeV, $\gamma$ spectra from, (E)
— deuteron reactions (d,p) at 17 MeV, angular distributions for, (E) (L.T.W.)

**18368** (RPI-328-179) THICK-SAMPLE NEUTRON TRANSMISSION MEASUREMENTS OF THE 229-eV RESONANCE IN $^{65}$Cu Yamamuro, N.; Block, R. C. (Rensselaer Polytechnic Inst., Troy, N. Y.). [1969]. Contract AT(30-1)-328. 6p. Dep. CFSTI.

Thick-sample neutron transmission measurements were carried out upon copper to determine the orbital angular momentum of the 229-eV resonance in $^{65}$Cu. Characteristic s-wave resonance-potential interference was observed in the transmission data, and together with reported capture spectra results, leads to a $J^{\pi}$ of $2^-$ for this resonance. A neutron width of (15 ± 1.5) MeV is obtained from this measurement. (auth)

**18369** STRUCTURE OF $^{51}$Ti. Divadeenam, M.; Beres, W. P. (Duke Univ., Durham, N. C.). Phys. Lett.; 30B: 598-602 (22 Dec 1969).

The gross experimental features of the low-lying negative parity states in $^{51}$Ti are reproduced basing the structure on single n, 2p-1h n and core plus n states. Most calculations do not consider the latter modes as distinct alternatives. (auth)

**18370** IZOBARNYE YADRA S MASSOVYM CHISLOM A = 75. (Isobar Nuclei with Mass Number A = 75). Zolotavin, A. V. Svoistva Atomnykh Yader, Vypusk 9. Leningrad; Izdatel'stvo Nauka Leningradskoe Otdelenie (1969). 80p.

The available experimental data on A = 75 nuclei are tabulated and summarized. The data include beta energies, gamma transition, decay schemes, quantum characteristics of excited states and other properties. The most reliable data are distinguished from that which requires further work. (J.W.R.)

**18371** MEASUREMENTS OF THE QUADRUPOLE MOMENT OF THE FIRST EXCITED STATE OF THE NUCLEI $^{74}$Ge, $^{76}$Ge, AND $^{108}$Pd BY HEAVY ION COULOMB EXCITATION. Grissmer, David Waltz. Lafayette, Ind.; Purdue Univ. (1969). 254p. Thesis.

The quadrupole moments of excited states in nuclei give direct information on the shape of the nucleus. Measurements of the quadrupole moments of the first excited state of the nuclei $^{74}$Ge, $^{76}$Ge, $^{108}$Pd were made using heavy ion Coulomb excitation with 25.0 MeV $^{16}$O ions. The excitation probability was measured as a function of scattering angles. A coincidence between the scattered ion and the de-excitation gamma ray separated the elastic and inelastic events. Perturbation theory shows that a deviation of the excitation probability from first order theory is proportional to the quadrupole moment of the excited state. Comparison of the measured excitation probability to first order theory gives for the quadrupole moments of the first excited state of the nuclei, $^{74}$Ge, $Q = -0.08 \pm 0.10$ barns, $^{76}$Ge, $Q = -0.03 \pm 0.10$ barns, and $^{108}$Pd, $Q = -0.33 \pm 0.17$ barns. (Diss. Abstr. Int., B)

**18372** A STUDY OF THE LEVELS OF $^{69,71}$Ga VIA (n,n'$\gamma$) REACTIONS. Veikley, Donald E. Lexington, Ky.; Univ. of Kentucky (1968). 65p. Thesis.

The level structures of $^{69,71}$Ga were studied by observing the gamma rays following neutron inelastic scattering by a target of metallic gallium. The gamma rays were observed with a shielded Ge(Li) detector using pulsed beam techniques to eliminate background. Measurements of gamma-ray production cross sections as a function of incident neutron energy from 0.60 to 2.5 MeV permitted the unambiguous determination of level energies as well as decay schemes and branching ratios for the two isotopes of gallium. Levels in $^{69}$Ga were observed at excitation energies of 319, 573, 873, 1027, 1108, 1334, 1527, 1724, 1893, 1924 and 2025 keV. Levels in $^{71}$Ga were observed at 390, 487, 512, 911, 965, 1108, 1474, 1487, 1495, 1700 and 1750 keV excitation energy. Two additional levels at 1395 and 2010 keV excitation were observed but could not be definitely placed in either isotope. Uncertainties of the excitation energies are ±1 keV. Gamma-ray angular distributions were measured at incident neutron energies of 0.65, 0.80, 1.50 and 1.78 MeV. The interpretation of angular distribution and neutron inelastic scattering cross section measurements in terms of the statistical model of nuclear reactions permitted unambiguous spin assignments to be made to seven levels and limits to be placed on the possible spin of five others. In addition, measurements of multipole mixing parameters have permitted a tentative parity assignment to one level. These assignments are $E_x$, $J^{\pi}$: 319, $\frac{1}{2}$; 573, $\frac{5}{2}$; 873, $\frac{3}{2}$; 1108, $\leq \frac{5}{2}$; 1334, $\frac{7}{2}$ in $^{69}$Ga. In $^{71}$Ga 390, ($\frac{5}{2}$, $\frac{7}{2}$); 487, $\frac{5}{2}$; 512, $\frac{3}{2}$; 911, ($\frac{1}{2}$, $\frac{3}{2}$); 965, $\frac{7}{2}$; 1108, ($\frac{7}{2}$, $\frac{9}{2}$); 1495, ($\frac{9}{2}$, $\frac{11}{2}$). (Diss. Abstr. Int., B)

**18373** LOW-LYING LEVELS OF $^{35}$Cl AND $^{37}$Cl. Duncan, Don Darryl. Lexington, Ky.; Univ. of Kentucky (1968). 95p. Thesis.

Triple angular correlation and measurements were made using the $^{35}$Cl(p,p'$\gamma$)$^{35}$Cl and $^{37}$Cl(p,p'$\gamma$)$^{37}$Cl reactions and the results were analyzed by method II of Litherland and Ferguson to obtain spins and multipole amplitude mixing ratios for the 1.220, 1.762, 2.645, 3.006, and 3.163-MeV levels of $^{35}$Cl and the 1.726-MeV level of $^{37}$Cl. The phase convention for the multipole amplitude mixing ratio $\delta$ is specified by Ferguson. Gamma-ray branching ratios for these levels and the 2.695-MeV level of $^{35}$Cl were also measured. Energy level assignments for all of the above levels of $^{35}$Cl were investigated with a Ge(Li) crystal detector. $CdCl_2$ enriched in $^{35}$Cl or $^{37}$Cl and evaporated onto thin gold backings was used as a target. Selected incident proton energies in the range 4.70 to 5.42 MeV provided an adequate yield of the p' groups. The inelastically scattered protons were observed near 180° with an annular surface-barrier detector, and the gamma rays were detected with a NaI(Tl) crystal which was placed at various angular positions in the reaction plane. For each level which was studied there is more than one spin assignment which is permitted by the data fitting, but other information places limits on the spin values in all cases except the 3.006-MeV level of $^{35}$Cl. (Diss. Abstr. Int., B)

**18374** YIELDS OF SOME LONG-LIVING SPALLATION PRODUCTS IN COPPER WITH 600 MeV BREMSSTRAHLUNG. di Napoli, Vito; Margadonna, Daniele; Salvetti, Franco (Univ., Rome). Ric. Sci.; 39: 133-7(Feb 1969). (In Italian).

Preliminary results on the yields of some gamma-spallation products from copper are given. These results seem to be consistent with those of previous similar studies. (auth)

**18375** MEASUREMENTS OF (d,n) REACTIONS ON $^{58}$Ni, $^{60}$Ni, $^{62}$Ni, AND $^{64}$Ni AT 5 AND 10 MeV. Marusak, Alex Louis. Knoxville, Tenn.; Univ. of Tennessee (1969). 147p. Thesis.

Absolute differential cross sections for $^{58}$Ni(d,n)$^{58}$Cu, $^{60}$Ni(d,n)$^{61}$Cu, $^{62}$Ni(d,n)$^{63}$Cu, and $^{64}$Ni(d,n)$^{65}$Cu at 5 and 10 MeV were measured by time-of-flight techniques in order to obtain energy levels, l-values, and spectroscopic strengths for the odd-A copper isotopes, and to compare these results with those obtained from the ($^3$He,d) and ($\alpha$,t) proton stripping reactions. Pulsed deuteron beams with pulses of one nsec FWHM and currents of one to two $\mu$A were obtained from 5.5 MeV Van de Graaff and the Tandem Van de Graaff accelerators. Neutrons were detected in 2-inch thick liquid scintillators optically coupled to photo-tubes. Gamma rays were discriminated against to reduce background, and the deuteron beam was monitored by measuring elastically scattered deuterons with a silicon surface-barrier detector. Measurements were made at angles ranging from 15 to 120° with flight paths varying from 7 to 34 m. Flight times for ground state neutrons from $^{58}$Ni(d,n)$^{58}$Cu were measured with a resolution of about 2 nsec. All data were accumulated in a PDP-7 computer. Peak areas and centroids were extracted by means of a light pen which interacted with the PDP-7 by detecting light from an oscilloscope display. Absolute efficiency of the neutron detectors was calculated with a Monte Carlo computer program. Angular distributions were compared with predictions of DWBA theory using optical model potentials of the Woods–Saxon form, taking into account nonlocality, spin-orbit terms, and finite-range effects in the (p,n) interaction. Optical model parameters were obtained from elastic scattering of deuterons on $^{60}$Ni. Angular distributions predicted by DWBA analysis agreed well with the 10 MeV data but poorly with the 5 MeV data. Spectroscopic strengths were obtained for 14 levels in $^{58}$Cu, 19 levels in $^{61}$Cu, 10 levels in $^{63}$Cu, and 19 levels in $^{65}$Cu. Agreement with spectroscopic strengths obtained from ($^3$He,d) measurements was good. Relative spectroscopic strengths of the first few low-lying levels in the odd-A copper isotopes are in marked disagreement with those predicted by the simple excited-core model, but in fair agreement with predictions of more extended models. (Diss. Abstr.)

**18376** LEVEL-CROSSING EXPERIMENT FOR INVESTIGATION OF THE HYPERFINE STRUCTURE OF THE EXCITED $3^2P_{\frac{1}{2}}$ STATE OF $^{23}$Na. Baumann, M. (Univ., Tuebingen, Ger.). Z. Naturforsch., 24a: 3049-57(July 1969). (In German).

The hyperfine structure of the $3^2P_{\frac{1}{2}}$-state of $^{23}$Na was investigated by means of the level-crossing-technique. $\Delta m = 2$ and $\Delta m = 1$ crossing signals were detected by observing the field-dependence of the polarization of the fluorescence radiation in a magnetic field. From a detailed analysis of the experimental signal curves one obtains the magnetic hfs splitting constant $A = (18.8 \pm 0.15)$ MHz, the electric quadrupole interaction constant $B = (2.9 \pm 0.3)$ MHz and the lifetime of the excited $3^2P_{\frac{1}{2}}$-state $\tau = (1.59 \pm 0.04) \cdot 10^{-8}$ sec. The nuclear electric quadrupole moment deduced from the ratio B/A is $Q(^{23}Na) = (0.124 \pm 0.015) \cdot 10^{-24}$ cm$^2$ (without Sternheimer correction). (auth)

**18377** THE POLARIZATION OF ELASTICALLY SCATTERED PROTONS ON Al, Cu, Zn, AND Mg NUCLEI AT LOW ENERGIES. Borsaru, M.; Cenja, M.; Hategan, C.; Tanase, M. (Inst. of Atomic Physics, Bucharest). Rev. Roum. Phys.; 14: 715-22(1969).

The angular distributions of the polarization of the elastically scattered protons on Al, Cu, Zn, Mg natural targets were measured at low energies. The experimental results were compared with optical model calculations performed with Rosen's parameters. (auth)

**18378** A THEORETICAL ESTIMATION OF THE WOLFENSTEIN PARAMETERS R AND A FOR 12-MeV $^3$He ELASTIC SCATTERING BY DIFFERENT NUCLEI USING S.A.M. THEORY OF FRAHN AND VENTER. Boca, I. (Inst. of Atomic Physics, Bucharest). Rev. Roum. Phys.; 14: 771-80(1969).

By means of the strong absorption model of Frahn and Venter the Wolfenstein parameters R and A for 12-MeV $^3$He elastic scattering on $^{24}$Mg, $^{40}$Ca, $^{45}$Sc, $^{46}$Ti, $^{49}$Ti, $^{50}$Ti, $^{51}$V, $^{54}$Fe, $^{58}$Ni, and $^{64}$Zn were calculated. No comparison with experimental data was made but a possible experiment using a polarized helion source is described. It is hoped that these theoretical predictions will be helpful in the planning of such experiments. (auth)

**18379** ABSORPTION OF GAMMA QUANTA BY MANGANESE NUCLEI IN THE GIANT-RESONANCE REGION. Dolbikin, B. S.; Isakov, A. I.; Korin, V. I.; Lazareva, L. E. (Lebedev Inst. of Physics, Moscow). JETP Lett. (USSR) (Engl. Transl.); 10: 231-2(20 Oct 1969).

Translated from Zh. Eksp. Teor. Fiz. Pis'ma Redaktsiyu; 10: 365-6(20 Oct 1969).

The total nuclear cross section for the absorption of gamma quanta by $^{55}$Mn was measured in the energy range 10 to 30 MeV by the absorption method. The results were compared with calculations by the dynamic collective model. (J.W.R.)

**18380** STRONG ABSORPTION MODEL ANALYSIS OF $^3$He ELASTIC SCATTERING. Boca, I. (Inst. of Atomic Physics, Bucharest). Rev. Roum. Phys.; 14: 497-513(1969).

The elastic differential cross-section distribution of $^3$He particles by $^{24}$Mg, $^{40}$Ca, $^{45}$Sc, $^{46}$Ti, $^{49}$Ti, $^{50}$Ti, $^{51}$V, $^{54}$Fe, $^{58}$Ni, $^{64}$Zn, and $^{90}$Zr were analyzed in terms of the strong absorption model. It is shown that with four parameters of this model good agreement with experiment is found. The values of radius parameter $r_s$, the diffuseness parameter d, the real phase parameter $\mu/4\Delta$ and the strength of spin-orbit $\nu$ resulting from the analysis are presented. For the obtained parameters the corresponding elastic angular distribution of polarization are also illustrated. In conclusion it is shown that it would be desirable to carry out measurements of polarization to test the validity of the $\nu$ parameters. (auth)

**18381** DECAY OF 81 SEC $^{59}$Cu. Luukko, A.; Holmberg, P. (Univ. of Helsinki). Soc. Sci. Fenn., Comment. Phys.-Math.; 34: No. 5, 31-4(1968).

The decay of 81$^s$ $^{59}$Cu was studied and new gamma rays at energies 424, 838, 1340, and 1395 keV were found. Gamma-ray energies and intensities were measured and a level scheme, which accounts for the new findings, was constructed. (auth) (Finland)

**18382** BRANCHING RATIOS FOR EXCITED STATES IN $^{25}$Al. Holmberg, P.; Luukko, A. (Univ. of Helsinki). Soc. Sci. Fenn., Comment. Phys.-Math.; 34: No. 4, 25-9(1968).

The branching ratio for the second excited state in $^{25}$Al was determined as $(51 \pm 2)/(49 \pm 2)$ (cross-over/cascade). The $E_p = 2010$ keV resonance feeds strongly the first excited state in $^{24}$Mg, and the relative yields of the $^{24}$Mg(p,p')$^{24}$Mg and $^{24}$Mg(p,$\gamma$)$^{25}$Al reactions at $E_p = 2010$ keV were determined as $\Gamma_p'/\Gamma_\gamma = 260$. (auth) (Finland)

**18383** COLLECTIVE VIBRATIONS IN ODD CU-ISOTOPES. Simons, L.; Sundius, T. (Univ. of Helsinki). Soc. Sci. Fenn., Comment. Phys.-Math.; 34: No. 9, 67-77(1969).

Excitation energies, spins and parities of the odd $^{59}$Cu, $^{61}$Cu, $^{63}$Cu, $^{65}$Cu and $^{67}$Cu nuclei were calculated. The excitation energies up to 2 MeV are in close agreement with the experiments. The phonon energy, the coupling parameter for the last odd proton and the core, and the dominating coefficients of the basic states show an abrupt change from $^{61}$Cu to $^{63}$Cu. This is obviously due to the formation of the $2p_{\frac{3}{2}}$, $1f_{\frac{5}{2}}$ neutron subshells. Electromagnetic moments and transition rates also were calculated. The magnetic moments are not, however, in agreement with the experiments and differ only slightly from the Schmidt values. Corrections to the magnetic moments were calculated by assuming a particle-hole excitation. (auth) (Finland)

**18384** A STUDY OF THE PRODUCTION AND PROPERTIES OF /sup 53m/Fe. Eskola, Kari (Univ. of Helsinki). Ann. Acad. Sci. Fenn., Ser. A VI; No. 261, 1-45(1968).

An isomeric state with a half-life of 2.58 ± 0.03 min, and an excitation energy of 3.04 MeV, was discovered in $^{53}$Fe. The following gamma rays were observed in its decay: 701.7 ± 0.2 keV (100%), 1011.1 ± 0.8 keV (84%), 1329.0 ± 0.8 keV (84%), and 2341.2 ± 1.2 keV (16%). A study of the decay properties of the isomer, and a comparison with theoretical shell model calculations, suggest that the isomeric state is a three-particle one with a spin of $\frac{19}{2}^-$. Cross sections, together with cross-section ratios of the isomeric pair of $^{53}$Fe, were determined for the reactions $^{54}$Fe(p,pn)$^{53}$Fe, $^{55}$Mn(p,3n)$^{53}$Fe, $^{54}$Fe(p,p3n)$^{53}$Fe, $^{58}$Ni(p,3p3n)$^{53}$Fe, and $^{59}$Co(p,2p5n)$^{53}$Fe for proton energies ranging from the reaction thresholds up to energies well above those corresponding to cross-section maxima. An analysis is presented of isomeric ratios in terms of the statistical theory of nuclear reactions. It is shown that the isomeric ratios calculated are markedly dependent upon the spin value assumed for the isomeric state. Close agreement exists between the calculated and experimental isomeric ratios if the isomeric state has a spin value of $\frac{19}{2}$. (auth) (Finland)

**18385** THE NUCLEAR STRUCTURE OF $^{86}$Rb. Dawson, John W. Tallahassee; Florida State Univ. (1969). 157p. Thesis.

The reactions $^{85}$Rb(d,p)$^{86}$Rb and $^{87}$Rb(d,t)$^{86}$Rb were initiated in isotopically enriched targets with 12-MeV deuterons from a tandem accelerator. The reaction products were analyzed and detected at a number of angles with a magnetic spectrograph. Q-values, excitation energies, and cross sections for levels in $^{86}$Rb below 2.5 MeV were determined. Proton angular distributions were analyzed by means of distorted-wave Born-approximation stripping theory. The low lying excited states of $^{86}$Rb populated by primary and secondary gamma-ray transitions from the $^{85}$Rb(n,$\gamma$)$^{86}$Rb thermal neutron capture reaction were studied. Ge(Li) detectors were used in the gamma-ray energy and cross section measurements. Both enriched $^{85}$Rb and natural rubidium targets were employed in the study. High energy primary gamma-

ray spectra were obtained and used to infer excitation energies of states to 2.5 MeV. Data from the (d,p), (d,t), and high energy (n,γ) measurements were combined with the low energy secondary gamma-ray measurements and a level and decay scheme was proposed for excited states below 1.5 MeV. The energy level spectrum emerging from this work was used to determine the applicability of the odd group shell model to $^{86}$Rb. A zero-range central force calculation of the protron and neutron hole configurations ($\pi p_{\frac{3}{2}}^{-1}$, $\nu g_{\frac{9}{2}}^{-1}$), ($\pi f_{\frac{5}{2}}^{-1}$,$\nu g_{\frac{9}{2}}^{-1}$), ($\pi p_{\frac{3}{2}}^{-1}$,$\nu p_{\frac{1}{2}}$), and ($\pi f_{\frac{5}{2}}^{-1}$,$\nu p_{\frac{1}{2}}$) has been compared with experiment. (Diss. Abstr.)

**18386** DECAY OF $^{63}$Zn. Kiuru, A.; Holmberg, P. (Univ. of Helsinki). Z. Phys.; 233: 146-53(1970).

Investigation of the 38.8-min decay of $^{63}$Zn has resulted in 31 gamma-ray transitions in $^{63}$Cu. New levels not earlier reported in $\beta^+$-decay of $^{63}$Zn, but found in nuclear reactions, are suggested at 2,010.9 and 3,101 keV. It is assumed that the excited core model generates a multiplet of levels at 669.75 keV ($1/2^-$), 962.1 keV ($5/2^-$), 1,327.1 keV ($7/2^-$) and 1,546.6 keV ($3/2^-$). Intensities for intramultiplet transitions were found to be: 219.4 keV, <0.004 (in units of 200 for annihilation radiation), 292.4 keV, <0.004, 365.0 keV, 0.03 ± 0.03, 584.4 keV, <0.005, and 876.8 keV, <0.005. (auth)

**18387** THE REACTIONS $^{48}$Ca(d,t)$^{47}$Ca AND $^{48}$Ca($^3$He,α)$^{47}$Ca. Schmitt, D.; Santo, R. (Max-Planck-Institut fuer Kernphysik, Heidelberg). Z. Phys.; 233: 114-21(1970).

The reactions $^{48}$Ca(d,t)$^{47}$Ca and $^{48}$Ca($^3$He,α)$^{47}$Ca were measured at incident energies of 17 and 18 MeV, respectively, and analyzed by DWBA. Besides strong transitions to the ground state and two unresolved states at about $E_x$ = 2.60 MeV relatively strong transitions with l = 2 are observed at higher excitation energies in the ($^3$He,α) reaction. The observed l = 1 and higher l = 3 transitions are rather weak indicating that particle-hole components in the $^{48}$Ca ground state are relatively small. (auth)

**18388** OPTICAL MODEL ANALYSIS OF $^{28}$Si(d,d) ANGULAR DISTRIBUTIONS IN THE RANGE $E_d$ = 5.1 TO 12.8 MeV. Lacek, H.; Strohbusch, U. (Univ., Freiburg i. B.). Z. Phys.; 233: 101-13(1970).

Elastic scattering of deuterons on $^{28}$Si was measured in the energy range 1.5 to 6.5 MeV. An optical model analysis was performed at 5.1, 5.3, 5.5, 5.7, 5.9, 6.5, 9.0, 10.0, 10.9, 11.8, and 12.8 MeV. Good fits could be obtained in most cases. In order to get the energy dependence of the optical model parameters, straight lines were fitted to the values obtained at the different energies. A detailed study of the optical model parameter ambiguities was carried out. Transmission coefficients have been calculated from the optical potentials obtained. (auth)

**18389** THE (n,α) CROSS SECTIONS FOR NATURAL NICKEL, IRON, CHROMIUM, AND MOLYBDENUM IN A FISSION NEUTRON SPECTRUM. Freeman, N. J.; Barry, J. F.; Campbell, N. L. (Atomic Weapons Research Establishment, Aldermaston, Eng.). J. Nucl. Energy; 23: 713-21(Dec 1969).

A technique based on the absolute determination of He by a combination of vacuum fusion extraction and mass spectrometry was used to measure the (n,α) cross sections for nickel, iron, chromium and molybdenum samples which had been irradiated in the core of the Dounreay Fast Reactor. Particular care was taken to determine the He contribution due to impurities in the samples. The neutron flux was calculated from activation measurements on the threshold reactions $^{54}$Fe(n,p)$^{54}$Mn and $^{58}$Ni(n,p)$^{58}$Co in the samples. The values obtained for the cross sections averaged over a fission neutron spectrum ($\bar{\sigma}_F$) are: Ni, 4.7 (±0.6) mb; Fe, 0.18 (±0.04) mb; Cr, 0.17 (±0.06) mb and Mo, 0.13 (±0.03) mb. (auth) (UK)

**18390** MEASUREMENT OF THE CIRCULAR POLARIZATION OF NEUTRON-CAPTURE GAMMA RAYS FROM $^{36}$Cl, $^{90}$Y, AND $^{40}$K. Eichler, J.; Djadali, F. (Kernforschungszentrum, Karlsruhe, Ger. Univ. Karlsruhe, Ger.). Z. Phys.; 233: 154-9(1970). (In German).

The circular polarization of γ rays following the capture of polarized thermal neutrons in nuclei was measured. The degree of polarization confirmed the spin $2^+$ for the 0.777 MeV level of $^{90}$Y and the spin $0^-$ or $3^-$ for the 0.029 MeV level of $^{40}$K. Further, the E2/M1 mixing ratio of the 8.58 MeV decay to the ground state of $^{36}$Cl was measured. (auth)

**18391** (n,2n) CROSS SECTIONS AND ISOMERIC CROSS SECTION RATIOS OF $^{76}$Ge AND $^{165}$Ho IN THE ENERGY REGION OF 12.5 TO 18.5 MeV. Steiner, E.; Huber, P.; Salathe, W.; Wagner, R. (Univ., Basel). Helv. Phys. Acta; 43: 17-38(16 Feb 1970). (In German).

Cross sections of the $^{76}$Ge(n,2n)$^{75}$Ge and $^{165}$Ho(n,2n)$^{164g,m}$Ho reactions were measured at neutron energies from 12.5 to 18.5 MeV with the activation method. A Ge pin diode served as detector of the gamma activity of the irradiated samples. A method based on the statistical model was developed for the theoretical calculation of excitation functions and the results compared with the experimental values. Shell effects and pairing forces have been taken into account. The isomeric cross-section ratios were compared with the theory of Huizenga and Vandenbosch. The spin cutoff-parameter was calculated on the basis of the Fermi gas and the superconductor models. Using level density coefficients according to T. D. Newton's formula, good agreement between theory and experiment could be obtained for nuclei with low values of this parameter, whereas for nuclei with high values discrepancies were observed in the excitation functions. Some improvement was obtained by introducing a correction for gamma transitions which compete with neutron emission during the decay of the compound nucleus. (auth)

**18392** REACTION (d,α) IN $^{32}$S AND $^{40}$C NUCLEI. Teterin, E. D.; Denisov, A. E.; Kolalis, R. P.; Nemilov, Yu. A.; Pomytkin, V. F.; Romanov, V. S.; Sadkovskii, V. S. Izv. Akad. Nauk SSSR, Ser. Fiz., 33: 1350-3(Aug 1969). (In Russian).

Angular distributions of alpha particles from the above reactions were measured at E = 7 MeV. The sulfur target was prepared by sputtering indium sulfide InS in vacuum with the sulfur isotope being 99% enriched in $^{32}$S. The target thickness was 50 to 130 micrograms per cm$^2$ so that it was possible to separate out groups of alpha particles corresponding to 6-9 th excited states of $^{30}$P. Numbering of $^{30}$P levels was according to Janecke, Nucl. Phys. 111: 39 (1968). The error was ±20% for states 5 to 9, and ±10% for states 0 to 4. An expression is given for the angular distributions of the reaction products according to a statistical theory of nuclear reactions. Calculated angular distributions are given for concrete values of spin and parity, and are compared with experimental distributions. It is concluded that the $^{32}$S(d,α)$^{30}$P reaction passes through the formation of a compound nucleus and that the violation of the selection rule on isospin apparently can be ascribed to the mechanism of exciting the incident deuteron to the singlet state. The $^{40}$Ca(d,α)$^{38}$K reaction shows poor agreement between the theoretical angular distributions and the experimental values, which behavior may be explained by a direct interaction contribution. (TTT)

**18393** ELASTIC AND INELASTIC PROTON SCATTERING ON $^{23}$Na. Aptropov, A. E.; Zarubin, P. P.; Kudoyarov, M. F.; Orlov, B. N.; Plavko, A. V.; Sorokin, A. I. Izv. Akad. Nauk SSSR, Ser. Fiz., 33: 1379-83(Aug. 1969). (In Russian).

A proton beam was extracted from a cyclotron, deflected by 20°, and allowed to strike the $^{23}$Na target after passing through a system of collimating diaphragms. The target of metallic sodium was sputtered on a backing of carbon, silver or gold. In a number of cases a protective layer of silver was put on the sodium. Angular distributions of elastically and inelastically scattered protons with an energy of about 6 MeV were measured with excitation of $^{23}$Na levels up to 3.92 MeV inclusively. Details as to the nature of the levels in $^{23}$Na are discussed. (TTT)

**18394** SPECTRUM OF γ RAYS PRODUCED DURING THERMAL NEUTRON CAPTURE BY SULFUR NUCLEI. Egri, Sh.; Kardon, B.; Poch, L.; Sheresh, Z.; Zamori, Z. Izv. Akad. Nauk SSSR, Ser. Fiz., 33: 1259-62(Aug. 1969). (In Russian).

A uniform, well-collimated beam of thermal neutrons was allowed to strike a sulfur disk 2.6 cm in diameter and 2.3 cm long. For a natural mixture of sulfur isotopes a total of 98% of the thermal neutron captures takes place because of $^{32}$S which has a cross-section of 0.520 barns. The gamma spectrum was measured on a 4096-channel Ge(Li)-semiconductor detector having a resolution of 5.7 keV at a gamma energy of 123 keV, and 19.5 keV at a gamma energy of 7 MeV. The detection efficiency was determined as a function of gamma ray energy. Gamma ray energies and relative intensities are listed. (TTT)

**18395** DECAY SCHEME OF $^{84}$Y. Zaiteeva, N. G.; Kratsik, B.; Loshchilov, M. G.; Muziol, G.; Chang Tkhan Min; Shtrusnyi, Kh. Izv. Akad. Nauk SSSR, Ser. Fiz., 33: 1283-93(Aug. 1969). (In Russian).

Radioactive yttrium isotopes were produced by irradiating $SrCl_2$ with 120- or 660-MeV protons. Carrier-free radioactive yttrium was separated from the strontium by extraction with 0.75 M diethylhexylphosphoric acid in toluene. Two Ge(Li) detectors with sensitive volumes of 6 and 10 cm$^3$ and energy resolutions of 3.5 and 5 keV respectively for $^{60}$Co gamma rays were used in order to measure the gamma spectra of $^{84}$Y. Assignments of lines were determined on the basis of half-lives. Parts of the gamma spectrum are presented for energies from 400 to 2400 keV. Energy values and relative intensities of $^{84}$Y gamma rays are tabulated. Experimental electron conversion coefficients are compared with theoretical values in order to obtain the multipolarities of a number of transitions. A decay scheme for $^{84}$Y is presented. A number of conclusions are drawn about the nature of levels in $^{84}$Sr. (TTT)

**18396** ELECTRON-SCATTERING STUDIES ON $^{40}$Ca AND $^{48}$Ca. Eisenstein, R. A.; Madsen, D. W.; Theissen, H.; Cardman, L. S.; Bockelman, C. K. (Yale Univ., New Haven). Contract AT(30-1)-2726. Phys. Rev.; 188: 1815-30(20 Dec 1969).

The beam from the Yale University Electron Accelerator was used in systematic studies of the nuclear charge distributions of $^{40}$Ca and $^{48}$Ca. The beam energy has been varied between 20 and 60 MeV, and the angular distributions include angles between 70 and 150°. Elastic electron scattering had been used to obtain the rms radius of $^{40}$Ca, and a value for the difference between the $^{40}$Ca and $^{48}$Ca radii. The results indicate that this difference is not as large as that predicted by the $A^{\frac{1}{3}}$ rule, in agreement with the Stanford electron scattering work and the Chicago and CERN experiments on the spectra from muonic atoms. Inelastic scattering experiments also have been performed, yielding results for the reduced transition probability B(EL↑) and the transition radius $R_{tr}$ for the following states: $^{40}$Ca, 3.73-MeV (3−), 3.90 (2+), 6.94 (2+, 3−); $^{48}$Ca, 3.83-MeV (2+) and 4.51-MeV (3−). (auth)

**18397** MASS AND ENERGY LEVELS OF $^{30}$Al. Ajzenberg-Selove, F. (Haverford Coll., Pa.); Igo, G. Phys. Rev.; 188: 1813-14(20 Dec 1969).

The $^{30}$Si(t,$^3$He)$^{30}$Al reaction was studied with 20-MeV tritons and an Elbek-type spectrograph. The atomic-mass excess of $^{30}$Al was determined to be −15.90 ± 0.04 MeV. Excited states of $^{30}$Al are observed with $E_x$ = 0.25 ± 0.03, 0.694 ± 0.015, (1.00 ± 0.03), 1.135 ± 0.020, and 1.262 ± 0.015 MeV. (auth)

**18398** MEAN LIFETIMES AND BRANCHING RATIOS OF LOW-LYING LEVELS IN $^{33}$S. Ragan III, C. E. (Duke Univ., Durham, N. C. Triangle Universities Nuclear Lab., Durham, N. C.); Moss, C. E.; Poore, R. V.; Roberson, N. R.; Mitchell, G. E.; Tilley, D. R. Phys. Rev.; 188: 1806-12(20 Dec 1969).

The mean lifetimes of the levels of $^{33}$S below 3.3-MeV excitation energy were measured by the Doppler shift attenuation method. The $^{30}$Si(α,n)$^{33}$S reaction was used to populate these states. $SiO_2$ targets (enriched to 95% in $^{30}$Si) evaporated onto Ni backings were bombarded with α-particles ranging in energy 5.5 to 9.0 MeV. γ-ray spectra were recorded with a 20-cc Ge(Li) detector at 0, 90, and 510° to the beam. The following mean lifetimes were found: τ(0.842-MeV level) = 1.66 ± 0.34 psec, τ(1.968) = 182 ± 22 fsec, τ(2.313) = 183 ± 25 fsec, τ(2.869) < 15 fsec, τ(2.937) > 4 psec, τ(2.970) = 82 ± 12 fsec, τ(3.221) < 65 fsec. The branching ratios of the 2.970-MeV level were determined to be (90 ± 5)% to the ground state and (10 ± 5)% to the second excited state. (auth)

**18399** NEW ISOMER: $^{68m}$Cu. Ward, T. E.; Ihochi, H.; Meason, J. L. (Univ. of Arkansas, Fayetteville). Contract AT(40-1)-3285. Phys. Rev.; 188: 1802-6(20 Dec 1969).

Irradiation of natural Zn, Ga, and enriched $^{68}$Zn with 14.7-MeV neutrons was found to produce a new radioactivity with a half-life of 3.8 ± 0.1 min which was assigned as an isomer of $^{68}$Cu. The energies and relative intensities of those γ rays associated with the decay of 3.8-min $^{68m}$Cu are: 0.085 ± 0.001, 0.110 ± 0.001, 0.153 ± 0.001, 0.525 ± 0.001, 0.577 ± 0.002, 0.635 ± 0.001, 1.078 ± 0.002, 1.260 ± 0.002, and 1.338 ± 0.002 MeV, with relative intensities of 94.8 ± 0.6, 25.7 ± 1.0, 6.1 ± 0.8, 100.00, ~2.4, 15.8 (some summing of 0.525−0.110 MeV), 83.3 ± 1.3, 14.1 ± 2.0, and 11.8 ± 3.0, respectively. A maximum β-ray endpoint energy of 4.6 ± 0.1 MeV was observed. Coincidence measurements of the 0.085- and 0.525-MeV, γ rays indicate that these γ rays are associated with an isomeric transition to the 30-sec $^{68}$Cu ground state. (auth)

**18400** PARTICLE−γ-RAY ANGULAR-CORRELATION STUDY OF $^{57}$Ni IN THE REACTION $^{58}$Ni($^3$He,αγ)$^{57}$Ni. Gould, C. R.; Balamuth, D. P.; Hinrichsen, P. F.; Zurmuehle, R. W. (Univ. of Pennsylvania, Philadelphia). Phys. Rev.; 188: 1792-1801(20 Dec 1969).

The levels of $^{57}$Ni populated in the reaction $^{58}$Ni($^3$He,α)$^{57}$Ni were studied using the method of particle−γ-ray angular correlations. The α particles were detected at 0° with respect to the incident beam by a position-sensitive detector located at the focal point of a magnetic spectrometer. Four 7.6 × 10.2-cm NaI(Tl) crystals were used simultaneously to detect coincident γ rays at angles between 90 and 160°. Using l values known from previous work, the following spin-parity assignments are made for the levels indicated: 0.78 MeV $\frac{5}{2}^-$, 1.11 MeV $\frac{1}{2}^-$ ($\frac{3}{2}^-$), 2.59 MeV $\frac{7}{2}^-$, 3.24 MeV $\frac{7}{2}^-$, 3.71 MeV ($\geq\frac{1}{2}$), 3.85 MeV ($\frac{3}{2}$, $\frac{5}{2}$), 4.23 MeV ($\frac{3}{2}$, $\frac{5}{2}$, $\frac{7}{2}$), 4.56 MeV ($\leq\frac{7}{2}$), 5.22 MeV $\frac{7}{2}^-$, 5.56 MeV $\frac{3}{2}^+$, 6.00 MeV $\frac{3}{2}^+$. Branching ratios for the decays of these levels are presented, along with mixing rations for the stronger transitions. (auth)

**18401** THE (p,t) AND (p,$^3$He) REACTION ON (2s-1d) SHELL NUCLEI. Brunnader, Heinz. Berkeley, Calif.; Univ. of California (1969)- 176p.

Thesis.

The excitations of high isospin (T = 2) analog states in the $T_z$ = 0 and the $T_z$ = +1 A = 4n nuclei were measured for the entire (sd) shell using the (p,t) and (p,$^3$He) reactions induced by 45-MeV protons. Also, the reactions $^{40}$Ar(p,t)$^{38}$Ar and $^{40}$Ar(p,$^3$He)$^{38}$Cl were utilized to observe the first T = 3 analog states in the $T_z$ = 1 and $T_z$ = 2 nuclei. In addition to these high T states, a number of T = 1 analog states were also observed. The ratio of the observed cross sections for these T = 1 analog states was compared with the ratio predicted from the DWBA cross-section expressions. This predicted ratio is found to depend on the type of transition by which the final analog states are formed, and hence may be used to provide structural information on the analog without the use of detailed wave functions. The (p,t) reaction was further utilized to extend the range of known excitations in the nuclei $^{18}$Ne and $^{34}$Ar. All Coulomb displacement data in the (1p) and ($1d_{\frac{5}{2}}$) shells, including those derived from this work, were fitted to parameterized Coulomb displacement energy formulas derived in the jj-coupling low seniority and Wigner supermultiplet schemes. The results were used to predict the masses of yet unmeasured neutron deficient nuclei in this region. (Disser. Abstr.)

**18402** A RECOIL STUDY OF (p,n) AND (p,2n) REACTIONS FOR PROTON BOMBARDING ENERGIES OF 100 TO 400 MeV. Stalker, Allan Cecil. Pittsburgh; Carnegie-Mellon Univ. (1969). 100p.

Thesis.

Investigators have been speculating about the mechanism for simple nuclear reactions in the incident particle energy region of 100 to 400 MeV. Of the nucleon-2 nucleon reactions the (p,2n) reaction offers the fewest complications for determining reaction mechanism. The two possible mechanisms are thought to be a cascade neutron followed by the evaporation of a second neutron or two cascade neutrons leaving the residual nucleus with excitation energy insufficient for further particle evaporation. The results of cross section measurements on $^{56}$Fe and $^{63}$Cu and the recoil study on $^{63}$Cu were compared to calculated values from the VEGAS-EVAP digital computer programs which simulate the Serber model of nuclear reactions. A kinematic model for simple nuclear reactions, "KMSNR," was developed and compared to the experimental work. Based on the results of the comparison of the two calculation models with the experimental data it is concluded that the charge exchange scattering mechanism followed by evaporation of a neutron is the more dominant mechanism with light A nuclides and that multiple scattering with two cascade neutrons increases in importance with increasing A. (Disser. Abstr.)

**18403** PROPERTIES OF $^{34}$Cl LEVELS FROM THE $^{33}$S(p,γ)$^{34}$Cl REACTION. Graber, H. D. (Cornell Coll., Mount Vernon, Iowa); Harris, Gale I. Phys. Rev.; 188: 1685-97(20 Dec 1969).

Six resonances in the $^{33}$S(p,γ)$^{34}$Cl reaction in the range $E_p$ = 1.0 to 1.3 MeV have been investigated in order to obtain information on resonance and bound-state properties of $^{34}$Cl. Revisions of previously reported γ-ray decay schemes of all six resonances were required as a result of measurements with a 40-cc Ge(Li) detector. The decay properties of 11 bound states below $E_x$ = 4.0 MeV were determined. Significant changes from previous results were found for the 0.665-, 3.545-, and 3.598-MeV levels. The 0.665-MeV level was observed to decay only to the ground state, as opposed to the branching ratio 80:20 for decay to $^{34}$Cl (0) and $^{34}$Cl (1) reported from earlier NaI(Tl) work. Transitions were observed from resonance levels to both the 3.545- and 3.598-MeV levels, which were unresolved in previous γ-ray work. The lower level was observed to decay only to the 0.147-MeV ($3^+$) level, while the upper level branches to the 0.147- and the 2.720-MeV level. Angular-correlation measurements at the 1165-keV resonance yield J = 3 and 4, respectively, for the resonance and 2.376-MeV levels. The latter result is consistent with a previous prediction of $J^\pi = 4^+$ from shell-model calculations. The 2.376 → 0.147 ($3^+$) transition is highly mixed dipole-quadrupole ($\delta = -6.3^{+3.0}_{-2.2}$) in reasonable agreement with a value δ = −2.7 calculated with published wave functions. Angular distribution and strength measurements at the 1266-keV resonance yield $J^\pi = 2^+$ and 1, respectively, for the resonance and 0.665-MeV levels. Similar measurements at the 1071-keV resonance yield $J^\pi$ (Res.) = $1^+$ or $2^+$. For several other levels, limitations on the possible spin assignments are obtained from transition speed considerations. Lower limits for the lifetimes of six bound states were obtained from Doppler-shift attenuation measurements at four resonances. New, more precise, values for the excitation energies of 12 bound states of $^{34}$Cl were obtained from Ge(Li) spectra. The $^{33}$S(p,γ)$^{34}$Cl reaction Q value was found to be Q = 5140.3 ± 1.5 keV. This value is 15 ± 6 keV lower than the value Q = 5155 ± 5 keV given in the 1964 Mass Tables. The possible location of members of the ($d_{\frac{3}{2}}f_{\frac{7}{2}}$) odd-parity spectrum is discussed. (auth)

**18404** A STUDY OF THE $^{50}$Cr(d,n)$^{51}$Mn AND $^{54}$Fe(d,n)$^{55}$Co REACTIONS. Nilsson, L. (Aktiebolaget Atomenergi, Studsvik, Sweden); Erlandsson, B. Z. Phys.; 232: 303-24(1970).

The $^{56}Cr(d,n)^{57}Mn$ and $^{54}Fe(d,n)^{55}Co$ reactions were studied at an incident deuteron energy of 5.5 MeV. Angular distributions of neutron groups to a number of low-lying levels in the residual nuclei were recorded. Time-of-flight techniques were used to record neutron spectra. A liquid scintillator with pulse-shape discrimination property has been used as neutron detector. DWBA calculations were performed and relative spectroscopic strengths determined for transitions with various $l_p$ values. The ratios between spectroscopic strengths for $l_p = 3$ and $l_p = 1$ transitions were found to be considerably larger than corresponding ratios obtained from the ($^3$He,d) reactions. Two-step stripping processes competing with the direct stripping process are suggested as explanation of the discrepancy between the (d,n) and the ($^3$He,d) results. (auth)

## Nuclear Properties and Reactions, A ≥ 90

*Refer also to abstracts 16446, 16873, 18358, 18361, 18367, 18371, 18380, 18381, 18390, 18391, and 18463.*

**18405** (BNL-14200) GAMMA-RAY SPECTRA FOLLOWING CAPTURE OF EPITHERMAL NEUTRONS. Chrien, R. E. (Brookhaven National Lab., Upton, N.. Y.). 1 Dec 1969. 33p. (CONF-691203-1). Dep. CFSTI.

From Meeting of the American Nuclear Society on Nuclear Data for Shielding, San Francisco, Calif.

The usefulness of $\gamma$-ray spectroscopy in the study of epithermal neutron capture is examined. Progress in understanding nuclear structure, the capture reaction mechanism, and related topics in applied nuclear physics through the use of resonance $\gamma$-ray spectroscopy is discussed and some examples are presented. (J.W.R.)

**18406** (CONF-680461-6) NEUTRON YIELDS AND NEUTRON EMISSION PROBABILITY $P_n$ OF THE DELAYED NEUTRON EMITTERS IN THE FISSION OF $^{235}U$ BY THERMAL NEUTRONS. Schuessler, Hans-Dieter; Grimm, Werner; Herrmann, Guenter (Mainz Univ. (West Germany). Institut fuer Anorganische Chemie und Kernchemie). [1968]. 9p. (In German). Dep. CFSTI (U. S. Sales Only).

From Professional Commission on Nuclear Physics, Bad Neuenahr, Germany.

An experimental study was made to determine the half lives and the relative contributions of the iodine and bromine fractions to the various groups of delayed neutrons in the fission of $^{235}U$ by thermal neutrons. The relative neutron yields of individual neutron emitters and their contribution to the 55, 22, 5, 2, and 0.5 sec neutron groups are tabulated. The composition of the nonhalogenide fraction and their contribution to the total delayed neutron yield were also measured. The probabilities for the neutron emission of $^{87}Br$, $^{88}Br$, $^{89}Br$, $^{90}Br$, $^{93}Rb$, $^{94}Rb$, $^{137}I$, $^{138}I$, $^{139}I$, and $^{140}I$ were calculated. (J.S.R.)

**18407** (COO-1162-35) PRODUCTS FROM THERMAL-NEUTRON INDUCED FISSION OF $^{235}U$: A CORRELATION OF RADIOCHEMICAL CHARGE AND MASS DISTRIBUTION DATA. Wahl, A. C.; Norris, A. E.; Rouse, R. A.; Williams, J. C. (Washington Univ., St. Louis, Mo.). [1969]. Contract AT(11-1)-1162. 35p. (SM-122/116). Dep. CFSTI.

Mass and charge distribution data for fission products after prompt neutron emission were compiled and used to determine $\nu_t$, the average number of prompt neutrons emitted in forming products with complementary mass numbers ($A_1 + A_h = 236 - \nu_t$), and also $Z_p$ and $\sigma$, parameters in a new charge-distribution formulation. The compilation includes both new data and older data, some of it re-evaluated using current values for fission-product half-lives and delayed-neutron yields. The values of $\nu_t$ determined using Terrell's method with normalized chain yields are generally consistent with results derived from direct physical measurements. The $Z_p$ values, the most probable (or average) charge for isobars, derived from radiochemical data are also consistent with those determined by physical methods involving measurement of x-rays or beta-decay chain lengths. The new Gaussian width parameter $\sigma$ has a value of $0.56 \pm 0.06$, which corresponds to a full-width at half-maximum of $1.50 \pm 0.12$ charge units. The new charge-distribution formulation was used with the normalized chain yields to estimate "normal" independent yields for all fission products, for elements, and for isotones. The estimated "normal" yields for complementary elements ($Z_1 + Z_h = 92$) are essentially equal, as they should be. Comparison of estimated "normal yields for elements with sums of experimental independent yields for the isotopes, shows, where sufficient data exist, that even-Z elements have higher yields than odd-Z elements. The maximum in the "normal" isotone-yield curve occurs at N = 82, and the sum of the measured independent yields for the N = 82 isotones is ~30% higher. It is shown that the probable modes of fission (those giving asymmetric mass and charge division) occur only when the heavy fragment has 50 or more protons. (auth)

**18408** (ORNL-tr-2275) OBSERVATIONS OF THE DIRECTIONAL CORRELATION OF $^{110m}Ag$ (270 d). Cappeller, U.; Ganssauge, E.; Ulirich, W. Translated by Lynda H. Kern (Oak Ridge National Lab., Tenn.), from Z. Naturforsch.; 13a: 559 (1958). 3p. Dep. CFSTI.

The directional correlations of the $\gamma$ rays in the days of $^{110m}Ag$ were measured. The data were used along with other data to assign spins and parities for several states in $^{110}Cd$. In addition, the multipolarities for several $\gamma$ transitions were determined. (J.W.R.)

**18409** (UM-P-69/18) STRUCTURE IN THE GIANT RESONANCE OF $^{108}Pd$ AND OF $^{110}Pd$. Deague, T. K.; Muirhead, E. G.; Spicer, B. M. (Melbourne Univ., Parkville (Australia). School of Physics). 1969. 21p. Dep. CFSTI (U. S. Sales Only).

The $^{108}Pd$ photoneutron cross section was measured from threshold to 24.5 MeV by direct neutron detection. The $^{108}Pd(\gamma,p)$ and $^{110}Pd(\gamma,n)^{109m}Pd$ cross sections were measured from threshold to 29 MeV by counting residual $\gamma$-activity. The dynamic collective model predictions of Huber for $^{108}Pd$ and $^{110}Pd$ are in reasonable agreement with these cross sections in the giant resonance region, but a large amount of observed strength at energies less than 14 MeV and greater than 20 MeV is not accounted for by the model. The relative strengths of the proton and neutron production cross sections in $^{108}Pd$ are shown to be consistent with Morinaga's concept of an isospin-split giant resonance. Similar agreement is demonstrated for $^{103}Rh$, $^{90}Zr$, and $^{65}Cu$. However, the relative strengths in $^{58}Ni$ are found to be inconsistent with this concept. (auth)

**18410** (WAPD-T-2292) CONSEQUENCES OF VARIOUS PROPOSED NUCLEAR DATA. Staub, Alan; Swaja, R. E. (Bettis Atomic Power Lab., Pittsburgh, Pa.). Oct 1969. Contract AT-11-1-GEN-14. 6p. (CONF-691102-9). Dep. CFSTI.

From 17th Conference on Remote Systems Technology, San Francisco, Calif.

The $^{235}U$ fission spectrum was investigated by comparing calculated and experimental values for several quantities. The calculations were performed using the Watt, Harris, ENDF/B, and McElroy spectra. (J.W.R.)

**18411** (WAPD-TM-691) AN EVALUATION OF THE NEUTRON REACTION CROSS SECTIONS AND FISSION SPECTRUM OF $^{233}U$ FOR ENDF/B (LWBR DEVELOPMENT PROGRAM). Steen, N. M. (Bettis Atomic Power Lab., Pittsburgh, Pa.). Dec 1969. Contract AT(11-1)-Gen-14. 160p. Dep. CFSTI.

A review of the nuclear data of $^{233}U$ was conducted. Primary emphasis was placed on the neutron capture and fission cross sections, neutron yield per fission, and the fission neutron emission spectrum. The result of this review is an ENDF/B type compilation of nuclear data which are given in the Appendix. This compilation appears to correct the previous disagreement in epithermal $\alpha$ of $^{233}U$ and observed biases in calculated reactivity. These data have been subjected to several tests of validity for application in reactor design. Some of these tests are discussed in the body of the text. (auth)

**18412** THE BETA-DECAY HALF-LIFE OF $^{241}Pu$. Nisle, Robert G.; Stepan, Ivan E. (Idaho Nuclear Corp., Idaho Falls). Nucl. Sci. Eng.; 39: 257-8(Feb 1970).

The beta-decay half-life of $^{241}Pu$ was studied using a reactivity method. The decay curve indicates the existence of two components. A half-life of $14.63 \pm 0.27$ years was found for normal $^{241}Pu$. An activity with a half-life of $0.34 \pm 0.11$ years is postulated to be an isomeric state in $^{241}Pu$. (J.W.R.)

**18413** NUCLEAR STRUCTURE STUDIES FROM PROTON- AND DEUTERON-INDUCED REACTIONS ON $^{136}Xe$. Moore, Patrick Allen. Austin, Tex.; Univ. of Texas (1969). 282p. Thesis.

Proton and deuteron induced reactions on $^{136}Xe$ were analyzed to obtain nuclear structure information of the $^{135}Xe$, $^{136}Xe$, and $^{137}Xe$ isotopes. Isobaric analogue resonances in the proton elastic excitation functions were fitted using the shell model approach to reaction theory to extract quantitative nuclear structure information for the parent analogue states in $^{137}Xe$. The results of the elastic analysis are compared with a DWBA analysis of the $^{136}Xe(d,p)^{137}Xe$ angular distributions and the two analyses are found to be in excellent agreement. In all, 24 levels of $^{137}Xe$ were identified in the combined analyses, and spins, parities, and spectroscopic factors were determined for many of these states. A DWBA analysis of the $^{136}Xe(d,t)^{135}Xe$ angular distributions were also carried out, pro-

viding information on the structure of three levels of the $^{135}$Xe nucleus. Thirty-six levels of $^{136}$Xe were identified in the proton inelastic scattering data. The inelastic excitation functions for many of these states exhibit a resonant behavior characteristic of neutron particle-neutron hole excited states. The experimental inelastic proton angular distributions for the particle-hole states at the first ($f_{\frac{7}{2}}$), second ($p_{\frac{3}{2}}$), and fourth ($f_{\frac{5}{2}}$) analogue resonances were fitted to determine the hole structure of the particle-hole configurations. Using the results of this analysis in conjunction with the resonant behavior of the corresponding inelastic excitation functions, it was possible to determine the particle-hole configurations of, and arrive at spin assignments for, several of the states of $^{136}$Xe. (Diss. Abstr. Int., B)

**18414** R-MATRIX CALCULATION OF $^{239}$Pu FISSION CROSS SECTION. Cristu, M. I.; Petrascu, M.; Isbasescu, Alina (Inst. of Atomic Physics, Bucharest). Rev. Roum. Phys.; 14: 841-6 (1969).

A R-matrix calculation was carried out for $^{239}$Pu cross section in the energy range below 0.01 eV. A fairly good overall agreement was found with experimental data. The slight deviations which appear at higher energies might be accounted for by the approximations made by Vogt in deriving the resonance parameters used in the present work. (auth)

**18415** GAMMA–GAMMA DIRECTIONAL CORRELATIONS IN THE DECAY OF $^{192}$Ir. Khan, Mohammad Yar. Atlanta; Georgia Inst. of Tech. (1969). 73p.

Thesis.

Research on gamma-gamma directional corelations in the decay of $^{192}$Ir was undertaken employing a liquid nitrogen cooled lithium drifted germanium gamma detector of 30 cm$^3$ volume for one radiation and a conventional 3 × 3 inch NaI(Tl) detector for the other radiation. The use of a Ge(Li) detector permits gamma-gamma directional correlation experiments to be done directly on the individual gamma rays that are a part of the composite peaks. A standard fast-slow coincidence circuit with a resolving time of about 20 nanoseconds was used. In order to determine which gamma-gamma directional correlations were feasible, considerable coincidence work was performed. From these studies it was decided to do the following correlation experiments [gamma energies given in keV]: (468-417), (612-588), (588-296), (612-308), (316-604), (484-206), and (206-374). Measurements were made at angles of 90, 135, 180, 225, and 270°. The experimental results were interpreted in terms of the spins of the relevant excited levels of $^{192}$Pt and $^{192}$Os and multipolarity assignments of the gamma transitions. The (468-417) keV correlation experiment indicates a spin of 4 for the 1200-kev level in $^{192}$Pt and a nearly pure $E_2$ radiation for the 417 keV gamma. Spin 4 for the 1200-keV level was found consistent with the results of the (588-612) keV correlation experiment. The assignments of spin 3 to the 690 keV level in $^{192}$Os and the 921 keV level in $^{192}$Pt are in agreement with the experimental data on the (484-206), (308-612), and (316-604) keV correlations. The results of the (374-206) keV correlation experiment are consistent with spin 4 for the 580 keV level in $^{192}$Os. The multipolarities of the 296-, 308-, and 484-kev transitions were determined as predominantly $E_2$ with an admixture of one or two percent of $M_1$ radiation. The multipolarity of the 604 keV transition was found to be about 19 percent $M_1$ plus 81 percent $E_2$ radiation. (Diss. Abstr.)

**18416** NUCLEAR-CHARGE DISTRIBUTION: FRACTIONAL CUMULATIVE YIELDS OF $^{99}$Nb FROM THE LOW-ENERGY FISSION OF $^{233}$U, $^{235}$U, $^{238}$U, AND $^{252}$Cf MASS DISTRIBUTION: CUMULATIVE YIELDS OF MASSES 95, 99, 103, 105, 131, 132, 133, 140, 141, 143, 144, AND 147 FROM $^{252}$Cf. Harbour, Robert Myron. Columbia, Mo.; Univ. of Missouri (1969). 129p.

Thesis.

The fractional cumulative yield (FCY) of the 2.6-min isomer of $^{99}$Nb was measured for the thermal-neutron fission of $^{233}$U and $^{235}$U, the epithermal-neutron fission of $^{238}$U, and the spontaneous fission of $^{252}$Cf. The FCY of this $^{99}$Nb isomer was found to be 0.29 ± 0.01, 0.31 ± 0.02, 0.30 ± 0.03, and 0.30 ± 0.02 for $^{233}$U, $^{235}$U, $^{238}$U, and $^{252}$Cf fission respectively. Based on the limited $^{99}$Nb decay-scheme information available, beta-decay and comparative-lifetime systematics suggest that the 2.6-min $^{99}$Nb isomer is the low-spin isomer of $^{99}$Nb. The results listed above are consistent with an interpretation in which (a) the 2.6-min $^{99}$Nb is assumed to be the low-spin isomer, (b) the independent yields of $^{99}$Nb from each of the fissioning nuclei studied are those predicted on the basis of other measured fractional yields, and (c) the independent high-to-low spin isomer-yield ratio is approximately two for each of the low-energy fission processes investigated, in agreement with other measured independent isomer-yield ratios from thermal-neutron fission. The half-life of the long-lived isomer of $^{99}$Nb was redetermined on the basis of data from these experiments and other selected literature data. The resulting value of 2.6 ± 0.2 min is the most precise value of this half-life reported. No evidence was found for the existence of 1-min $^{101}$Nb from either the thermal-neutron fission of $^{235}$U or the spontaneous fission of $^{252}$Cf. Upper limits of 0.007 ± 0.004 and ~0.01 were set for the FCY of a 1-min $^{101}$Nb from $^{235}$U and $^{252}$Cf fission respectively. The cumulative yields of $^{97}$Zr, $^{101}$Mo, and $^{102}$Mo were measured radiochemically from the spontaneous fission of $^{252}$Cf. Additional cumulative yields for $^{95}$Zr, $^{99m}$Tc, $^{103}$Ru, $^{105}$Rh, $^{131}$I, $^{132}$Te, $^{133}$Xe, $^{140}$Ba, $^{141}$Ce, $^{143}$Ce, $^{144}$Ce, and $^{147}$Nd from $^{252}$Cf fission were measured using direct high-resolution gamma-ray spectroscopy on the gross fission products. The results of this work indicate definite fine structure in the mass-101 and mass-143 regions and possible fine structure in the mass-133 region. Fine structure has been observed in other low-energy fission processes in these mass regions. (Diss. Abstr.)

**18417** DELAYED NEUTRONS FROM LOW ENERGY PHOTOFISSION. Kull, L. A.; Bramblett, R. L.; Gozani, T.; Rundquist, D. E. (Gulf General Atomic Inc., San Diego, Calif.). Nucl. Sci. Eng.; 39: 163-9(Feb 1970).

The time behavior of delayed neutrons from the photofission of $^{238}$U and $^{235}$U was measured for bremsstrahlung endpoint energies of 8- and 10-MeV. The data were analyzed to determine the relative abundances ($\beta_i$) of the delayed-neutron groups assuming the observed time distribution can be adequately described by six groups. A comparison of the $^{238}$U results at 8- and 10-MeV, and other results at 15-MeV show no strong dependence of the $\beta_i$ on endpoint energy. In the case of $^{235}$U, no large differences were observed between the $\beta_i$ at 8- and 10-MeV, however there are marked variations for several groups at 15 MeV. Possible causes for the observed differences in the $\beta_i$ with endpoint energy are discussed. No evidence was found for the existence of a delayed-neutron group with a half-life in the 10 to 100 msec region. (auth)

**18418** DIRECT DETERMINATION OF THE LIFETIME OF EXCITED COMPOUND NUCLEI BY ANGULAR DISTRIBUTION MEASUREMENTS OF FISSION FRAGMENTS EMITTED FROM SINGLE CRYSTALS. Gibson, W. M. (Bell Telephone Labs., Murray Hill, N. J.); Nielsen, K. O. Phys. Rev. Lett.; 24: 114-17(19 Jan 1970).

The lifetime for decay of excited $^{238}$Np compound nuclei was determined by measuring the emission distribution of fission fragments from a uranium oxide single crystal bombarded with 10-MeV protons. The proton energy, and with this the compound nuclei excitation energies, were selected to give second-chance fission $^{238}$Np compound nuclei with lifetimes in the range detectable by this technique. (auth)

**18419** RADIOACTIVE DECAY OF $^{182}$Os. Plajner, Z.; Brabec, V.; Maly, L. (Nuclear Research Inst., Rez, Czech.). Czech. J. Phys.; 19: 1616-18(1969).

Gamma singles and coincidence spectra were measured for the decay of $^{182}$Os using Ge(Li) and NaI(Tl) detectors. In addition, the conversion electron spectra were studied with an iron-yoke double focusing spectrometer. Internal conversion coefficients and multipolarities for transitions in $^{182}$Re were determined. (J.W.R.)

**18420** GAMMA RADIATION FROM THE DECAYS OF $^{189}$Pt AND $^{191}$Pt. Plajner, Z.; Vejs, M.; Hnatowicz, V.; Prochazka, I. (Nuclear Research Inst., Rez, Czech.). Czech. J. Phys.; 19: 1622-5(1969).

Gamma singles and coincidence spectra from the decays of $^{189}$Pt and $^{191}$Pt were studied using Ge(Li) and NaI(Tl) detectors. The data were used along with previous data on conversion electron intensities to determine the internal conversion coefficients and multipolarities of transitions in $^{189}$Ir and $^{191}$Ir. (J.W.R.)

**18421** NEW TRANSITIONS OBSERVED IN $^{188}$Pt DECAY. Plajner, Z.; Hnatowicz, V.; Vejs, M. (Nuclear Research Inst., Rez, Czech.). Czech. J. Phys.; 19: 1620-2(1969).

The gamma energies and intensities in the decay of $^{188}$Pt were measured using Ge(Li) detectors. The data were used along with previous conversion electron measurements to determine internal conversion coefficients and multipolarities of transitions in $^{188}$Ir. (J.W.R.)

**18422** DECAY OF $^{119}$Te ISOMERS AND STRUCTURE OF $^{119}$Sb. Kantele, J.; Hattula, J.; Hattula, T.; Kalm, H.; Marttila, O. J. (Univ. of Helsinki). Ann. Acad. Sci. Fenn., Ser. A VI; No. 259, 1-28(1968).

The disintegrations of 16 h $^{119g}$Te and 4.7 d $^{119m}$Te were investigated with Ge(Li) and NaI(Tl) detectors and detector combinations. On the basis of a quantitative analysis of gamma-gamma coincidence spectra, all principal features of the decay schemes were established, in agreement with recent proposals in the literature.

From E.C./$\beta^+$ branching ratio measurements, an upper limit of 2.56 MeV is determined for the electron-capture disintegration energy of $^{119m}$Te. These measurements also suggest a disintegration energy of 2.24 MeV for the ground state of $^{119m}$Te. With the aid of a fast coincidence spectrometer, upper limits of 250 and 200 ps are obtained for the half-lives of the 270- and 1366-keV levels in $^{119}$Sb, respectively. The present half-life and the internal conversion data reported in the literature suggest that the 1366-keV gamma which connects the latter level to the ground state is of E3 character and has a speed of more than 10 s.p.u. This implies that the 1366-keV level is an $11/2^-$ state with strong collective octupole admixture. The reaction $^{118}$Sn($^3$He,d)$^{119}$Sb was studied with 19-MeV incident particles at an observation angle of 40°, the deuteron spectrum being recorded by a magnetic spectrograph. Several new levels observed in this reaction, together with levels populated in the decay of $^{119m,g}$Te, are discussed in light of relevant nuclear models. The present data are consistent with a strong proton-core interaction, since evidence is found for the odd particle being coupled to the quadrupole and octupole vibrations of the even-even core. (auth) (Finland)

**18423** GAMMA-GAMMA ANGULAR CORRELATIONS IN $^{130}$Xe. Holmberg, P.; Luukko, A. (Univ. of Helsinki). Soc. Sci. Fenn., Comment. Phys.-Math.; 34: No. 1, 1-8(1968).

A study was made of the decay of the ground state of $^{130}$I. It is apparent from the analysis of gamma-ray spectra that not only the levels at 536, 1204, 1944 and 2362 keV, but also the 1121 keV level in $^{130}$Xe are observable in the decay of 12.4$^h$ $^{130}$I. Moreover, a new level at 1807 keV is suggested. This level decays to the first, second and third excited states in $^{130}$Xe. Gamma-gamma directional correlation measurements were made in $^{130}$Xe, involving the 418-, 536-, 668-, 740-, and 1157-keV gamma rays. The results are consistent with the following spin assignments: g.s. $0^+$, 536 keV $2^+$, 1121 keV $2^+$, 1204 keV $4^+$, 1807 keV $(3^+)$, 1944 keV $6^+$ and 2362 keV $5^{(+)}$. The 536-, 668- and 740-keV transitions are pure E2 transitions, and the 418- and 1157-keV gamma rays are 90 to 94% dipole and 6 to 10% quadrupole transitions. (auth) (Finland)

**18424** $\gamma$ TRANSITIONS IN THE DECAY OF $^{99}$Mo. Bashandy, E. (Atomic Energy Establishment, Cairo). Z. Naturforsch.; 24a: 1893-7(Dec. 1969).

The internal conversion spectrum of $\gamma$ transitions in the decay of $^{99}$Mo was re-studied using a high-resolution double-focusing $\beta$-ray spectrometer. In addition to $\gamma$ rays previously reported, seven more $\gamma$ rays could be observed. Internal conversion coefficients and multipolarities of $\gamma$ transitions are given. Energies, spins, and parities of high excited levels in $^{99}$Tc are confirmed. (auth)

**18425** INTERPRETATION OF THE ENERGY SPECTRUM OF $^{183}$W. Naepfel, H. (Univ., Erlangen, Ger.). Z. Naturforsch.; 24a: 1883-92(Dec 1969). (In German).

The energy levels of $^{183}$W are calculated in a nuclear model consisting of three point masses. Two of them with equal masses within a fixed distance $\rho_0$ represent the core of the nucleus. The third one, representing the extra nucleon, is assumed to move in a potential of the usual Nilsson type. For the description of the nuclear deformation a term $P_4$ is added. In contrast to former calculations it can be shown that a consistent set of parameters exists which fits the experimental data including the level $1/2^-$ at 453.1 keV. (auth)

**18426** MATRIX ELEMENTS OF THE 1.492-MeV $\beta$ TRANSITION IN $^{152}$Eu. Appalacharyulu, K. B.; Sastry, D. L.; Jnanananda, S. (Andhra Univ., Waltair, India). Indian J. Phys., 43: 113-22 (Mar. 1969).

The angular correlation of the $3^-$ ($\beta$/1.492MeV) $2^+$ ($\gamma$/0.343MeV) $0^+$ cascade in $^{152}$Eu decay was measured as a function of beta energy in the region 950-1400 keV. The present angular correlation results were combined with those on spectrum shape factor and beta-gamma circular polarization available from previous works to determine nuclear matrix elements governing the 1.492-MeV beta transition in $^{152}$Eu. The analysis was conducted on a CDC 3600 type computer employing the exact electron radial wavefunctions and taking into account the finite nuclear size effects. A comparison of the matrix elements obtained with those determined by earlier workers who used the approximate formulas of Kotani has shown that the present value of $\int (\vec{\Gamma}/\rho)$ is enhanced considerably, while the values of the other vector matrix elements are in agreement with the previous results within experimental errors. Experimentally determined ratio of the $\int i\alpha$ to $\int \vec{\Gamma}$ matrix elements is found to be 16.0 ± 5.0, which is not in agreement with the CVC prediction. The energy dependence of the circular polarization of the 343-keV gamma radiation is also predicted at an angle of 157° consistent with the matrix elements reported. (auth)

**18427** INVESTIGATION OF THE BETA DECAY OF THE GROUND STATE OF PROMETHIUM-148. Amadori, Robert Augustus. Amherst, Mass.; Univ. of Massachusetts (1969). 119p.

Thesis.

The beta-decay of the ground state of $^{148}$Pm was investigated by means of the beta-gamma directional correlation of the inner-beta-groups and beta-longitudinal polarization of the outer beta-group. The directional correlation involving the 1930-KeV $1^-(\beta)2^-(\gamma)0^+$ cascade in the decay of the 5.4d $^{148}$Pm was measured at nine beta-ray energies in the range 1050-1700 KeV using a beta-gamma coincidence scintillation spectrometer. An attempt is made to interpret the data in terms of the beta-decay matrix elements, and to determine the constant $\Lambda$ which relates the two matrix element parameters x and y [$y = \Lambda\xi x : \xi = (\alpha Z/2\rho)$]. The electron longitudinal polarization of the 2480-KeV beta-group is measured using the Møller scattering method. An attempt was made to interpret the results in terms of the structure of the ground state of $^{148}$Pm. The value of the matrix element ratio x, the magnetic moment and $\Lambda$ were calculated for the two ground state configurations (1) $f_{\frac{5}{2}}$ (neutron); $d_{\frac{5}{2}}$ (proton), and (2) $f_{\frac{5}{2}}$ (neutron); $g_{\frac{9}{2}}$ (proton), and compared with the experimental values for these quantities. Based on these comparisons, it appears that the ground state structure of $^{148}$Pm cannot be adequately described by a simple single particle configuration. Predictions for the $(f_{\frac{5}{2}}^3)_{\frac{5}{2}}$ (neutron); $g_{\frac{9}{2}}$ (proton) configuration were also investigated and much better agreement with experiment was shown. (Disser. Abstr.)

**18428** ELEMENT 103 OF THE PERIODIC SYSTEM. Donets, E. D.; Druin, V. A.; Mikheev, V. L. Ann. Phys. (Paris); 3: 331-9(Sep-Oct 1968).

The results of all the works, performed up to the present time, on the synthesis and the study of the properties of the element 103 isotopes were analyzed. It was concluded that the most reliable and complete data have been obtained for the isotope $^{256}$103. The half-life of this isotope is about 35 sec and its alpha emission spectrum is complex and lies between 8.3 and 8.5 MeV. To get the same degree of unambiguity in determining the properties of other isotopes of 103, in particular of $^{257}$103, some additional experiments are needed. (auth)

**18429** ANALYSIS OF CONVERSION ELECTRONS FROM THE (p,2n) AND (p,n) REACTION ON MEDIUM AND HEAVY NUCLEI. Goldman, Leonard Hillel. Pittsburgh; Univ. of Pittsburgh (1969). 69p.

Thesis.

Internal conversion electrons following (p,n) and (p,2n) reactions were studied with a six gap "orange" type beta ray spectrometer. Three previously unreported EO transitions are found in $^{196}$Hg, $^{204}$Pb and $^{208}$Po via the (p,2n) reactions on $^{197}$Au, $^{205}$Tl and $^{209}$Bi respectively. New levels with spin-parities are reported for $^{195}$Au which was studied by conversion electrons from the $^{196}$Pt (p,2n) $^{195}$Au reaction and the observations of tritons from the $^{197}$Au (p,t) $^{195}$Au reaction. The results from the (p,n) and (p,2n) reaction on $^{113}$In and $^{115}$In are presented and the location of the $6^+$ level in $^{114}$Sn is reported. In addition to the experimental results, the utility of the spectrometer in nuclear structure work is discussed. (Diss. Abstr. Int., B)

**18430** LEFT-RIGHT ASYMMETRY IN COMPTON SCATTERING ON POLARIZED ELECTRONS. Bock, P. (Univ., Karlsruhe, Ger. Kernforschungszentrums, Karlsruhe, Ger.). Phys. Lett.; 30B: 628-30(22 Dec 1969).

In Compton scattering on polarized electrons a left-right asymmetry of the order $10^{-3}$ has been observed which must be attributed to higher-order corrections of the scattering amplitude. This effect might provide a test of quantum electrodynamics. (auth)

**18431** A MEASUREMENT OF THE $\beta$ DECAY ENERGY FROM THE FISSION PRODUCTS OF $^{239}$Pu. McNair, A.; Keith, R. L. G. (Atomic Weapons Research Establishment, Aldermaston, Eng.). J. Nucl. Energy; 23: 697-703(Dec 1969).

A measurement of the energy released as kinetic energy of the electrons emitted in the radioactive decay of the fission products of $^{239}$Pu is described. The fission products were produced at a uniform rate over periods that ranged from 10 to $10^5$ sec and measurements of the energy were made at times ranging from 15 to $10^5$ sec after fission. (auth) (UK)

**18432** A MEASUREMENT OF THE THERMAL NEUTRON RADIATIVE CAPTURE CROSS SECTION OF $^{238}$U. Hunt, J. B.; Robertson, J. C.; Ryves, T. B. (National Physical Lab., Teddington, Eng.). J. Nucl. Energy; 23: 705-11(Dec 1969).

The $^{238}$U(n,$\gamma$)$^{239}$U cross section was measured using the standard thermal neutron flux facility available at the National Physical Laboratory. The $^{239}$U activity induced in the reaction was determined after irradiation by absolute counting techniques. Values of 2.69 ± 0.03 b for the 2200 m/sec capture cross section and 23.40 ±

0.05 m for the half life of the $^{235}U$ ground state were obtained. (auth) (UK)

**18433** DECAY OF $^{193m}Hg$. Plajner, Z.; Frana, J.; Rezanka, I.; Spalek, A.; Fiser, M. (Nuclear Research Inst., Rez, Czech.). Z. Phys.; 233: 122-32(1970).

The decay of $^{193m}Hg$ to $^{193}Au$ levels was investigated by means of Ge(Li)-Ge(Li) and Ge(Li)-NaI(Tl) coincidence spectrometers. In the $\gamma$-ray spectrum about 120 transitions were observed, about 80 of them being new. Forty coincidences between $\gamma$-transitions were observed. The level scheme of $^{193}Au$, including 12 earlier known levels as well as 17 new and corrected levels, has been constructed on the basis of the balance of energy sums and the observed coincidences. Possible multipolarities of 33 transitions were determined. Possible spins and parities of several levels were deduced from the determined multipolarities. (auth)

**18434** SPECTRA OF K-LL-AUGER ELECTRONS OF CADMIUM AND ANTIMONY. Babenkov, M. I.; Bobykin, B. V.; Povgorodov, A. F.; Taskarin, B. T. Izv. Akad. Nauk SSSR, Ser. Fiz., 33: 1304-8(Aug. 1969). (In Russian).

Radioactive substances decaying by K-capture to cadmium and antimony isotopes were used as sources. Radioactive $^{111}In$ ($T_{1/2}$ = 2.81 days) was formed by irradiating a natural mixture of silver isotopes with 40-MeV alpha particles. Carrier-free $^{111}In$ was isolated by precipitating with lanthanum hydroxide, and then separating In and La on a Dowex anion exchange column. The HCl eluate from the column was evaporated to dryness in a tantalum disk, and evaporated in vacuum onto an aluminum foil for observation of Auger electrons from cadmium. The $^{121}Te$ source, which decays by K-capture to $^{121}Sb$ ($T_{1/2}$ = 17 days), was formed by irradiating a natural mixture of antimony isotopes with 20-MeV alpha particles, precipitating Te with Se, separating Te from Se on an anion column, and evaporating in a vacuum onto an Al backing. The study of K-LL-electrons emitted by cadmium and antimony was carried out on a magnetic double-focusing betaspectrometer. Theoretically a total of 9 lines is expected between the two vacancies of the final state of an atom. The results of measuring the relative intensities of these lines are tabulated along with the average square error. A comparison of experimental intensities with calculated values was not carried out because a larger amount of experimental data is needed. (TTT)

**18435** GAMMA RADIATION OF $^{97}Rh$. Anton'eva, N. M.; Grigor'ev, E. P.; Katykhin, G. S.; Protasova, L. F.; Ryndina, E. Z.; Tishin, V. G. Izv. Akad. Nauk SSSR, Ser. Fiz., 33: 1309-14(Aug. 1969). (In Russian).

The $^{97}Rh$ isotope ($T_{1/2}$ = 32 min) is produced on irradiating cadmium with 660-MeV protons. A rhodium fraction was isolated with the use of partition chromatography on a porous fluorocarbon material. Measurements of gamma rays from $^{97}Rh$ were carried out with a Ge(Li)-detector having sensitive volumes of 5, 7.5 and 12.5 $cm^3$ with resolutions of 4.5 to 7 keV in the energy region from 50 to 3000 keV. Measurements were begun 15 to 40 minutes after target irradiation. Relative intensities of $^{97}Rh$ gamma rays are presented and compared with literature values. A decay scheme for $^{97}Rh$ is proposed. On decay of $^{97}Rh$ an increase in activity of the daughter radioactive isotope $^{97}Ru$ ($T_{1/2}$ = 2.7 days) is observed, and an analysis of the lower states of $^{97}Ru$ is carried out on the basis of the experimental data. (TTT).

**18436** DECAY OF $^{98}Pd$ AND $^{98}Rh$. Anton'eva, N. M.; Barkov, A. B.; Grigor'ev, E. P.; Katykhin, G. S.; Protasova, L. F. Izv. Akad. Nauk SSSR, Ser. Fiz., 33: 1299-1303(Aug. 1969). (In Russian).

Sources of $^{98}Pd$ ($T_{1/2}$ = 17.5 min) and $^{98}Rh$ ($T_{1/2}$ = 8.7 min) were prepared by irradiating a cadmium oxide target with 660-MeV protons, and subsequently isolating the rhodium fraction by chemical means. Measurements were carried out on a Ge(Li)-detector 20 to 30 min after the end of the irradiation, and 15 to 20 min after separating the palladium or rhodium fraction. Relative intensities for gamma rays in $^{98}Rh$ were found to be 4 for the 573-keV, 2.0 for the 607-keV, 100 for the 651.8-keV, <2 for the 745-keV, 7 ± 2 for the 808-keV, 4 ± 1 for the 966-keV, 3.5 ± 0.5 for the 1012-keV, 7 ± 2 for the 1164-keV, and 5 ± 1 for the 1228-keV gamma ray. A significant fraction for all $^{98}Rh$ decays go through the 651.8-keV transition. It was found that lg ft = 4.7 for the 2500 $\beta^+$-transition to the 651.8-keV level, that is, this is an allowed beta transition. Hence the preferred purity and total moment of the $^{98}Rh$ ground state is taken as $2^+$. A decay scheme is proposed for the decay of $^{98}Rh$ to $^{98}Ru$. Relative intensities for gamma rays in $^{98}Pd$ were found to be 100 for the 112-keV, 29 ± 3 for the 386-keV, and 43 ± 7 for the 661-keV gamma ray. The level schemes of the odd-odd nuclei $^{98}Rh$ and $^{100}Rh$ are compared. (TTT)

**18437** STUDY OF $^{124}I$ RADIATION. Bechvarzh, F.; Gromov, K. Ya.; Zhelev, Zh. T.; Zaitseva, N. G.; Loschilov, M. G.; Nazarov, U. K.; Sabirov, S. S. Izv. Akad. Nauk SSSR, Ser. Fiz., 33: 1329-34(Aug. 1969). (In Russian).

An iodine fraction was separated from a La or Ce target irradiated with 660-MeV protons. The source was prepared by evaporating the iodine on a silver foil. The internal conversion electron and positron spectra were studied by means of a double-focusing beta-spectrometer. The gamma ray spectrum was taken on Ge(Li)-detectors having sensitive volumes of 6 and 12 $cm^3$ and resolutions of 5.0 and 4.2 keV for the 1332-keV $^{60}Co$ line. A total of 28 K-conversion lines were observed. Three positrons were observed at limiting energies of 790 ± 30, 1520 ± 15 and 2136 ± 10 keV. The data on the intensities of gamma rays and of internal conversion electrons were used to determine internal conversion coefficients of the gamma transitions. The multipolarities of a number of transitions were determined by comparing the experimental and theoretical values of the internal conversion coefficients. A level scheme is given for the decay of $^{124}I$ with probable spin and parity values shown on the diagram. (TTT)

**18438** DECAY OF $^{120}Sb$. Kiselev, B. G.; Burmistrov, V. R. Izv. Akad. Nauk SSSR, Ser. Fiz., 33: 1340-2(Aug. 1969). (In Russian).

A 96.5% enriched $^{120}Sn$ target was irradiated with protons in a cyclotron to produce the $^{120}Sb$ activity ($T_{1/2}$ = 16 min). Gamma measurements were carried out on a semiconductor Ge(Li)-spectrometer from 500 to 1400 keV. The 1264.7-, 1171.2-, 987.6- and 707-keV gamma lines were clearly visible. The limiting energy of positrons from $^{120}Sb$ measured by a scintillation beta-spectrometer was found to be equal to 1750 ± 30 keV. A decay scheme for $^{120}Sb$ is presented with energy levels at 2375, 2159 and 1878 keV. The lg ft values for beta-decay to these levels correspond to spin values of 0, 1 and 2 with positive parity for each level. Since the intensity of direct gamma-transitions from these levels to the ground state of $^{120}Sn$ does not exceed 0.006% per decay, the value $O^+$ is indicated. (TTT)

**18439** RESONANCE FLUORESCENCE MEASUREMENTS OF $^{115}In$ TRANSITION STRENGTHS BELOW 3 MeV. Alston III, William J. (Boston Univ.). Phys. Rev.; 188: 1837-41(20 Dec 1969).

Gamma transition strengths $g\Gamma_0(M1 + E2)$ are measured for $^{115}In$ with electron bremsstrahlung resonant scattered from levels previously reported at 934, 1078, 1133, 1291, and 1450 keV. In addition, new transitions at 1495, 2277, 2438, 2476, and 2742 keV are seen for which $gW\Gamma_0^2/\Gamma$ is measured. E2/M1 mixing ratios are deduced in cases where $g\Gamma_0(E2)$ has been previously reported. (auth)

**18440** DECAY PROPERTIES OF $^{133}Sb$. Treytl, W. J. (Naval Radiological Defense Lab., San Francisco). Phys. Rev.; 188: 1831-7(20 Dec 1969).

Radiations from the decay of $^{133}Sb$ were studied with the use of solid-state and scintillator $\gamma$ and $\beta$ detectors. $\gamma$ transitions of $^{133}Sb$ with their relative percent intensities have been measured at 700.2 keV (73.9), 818.4 keV (29.4), 978.9 keV (100.0), 1096.7 keV (45.3), 2441.5 keV (14.5), and 2775.8 keV (26.1). Singles $\gamma$, $\gamma$-$\gamma$, and $\beta$-$\gamma$ measurements have been performed, and a decay scheme for $^{133}Sb$ has been constructed consisting of levels at 0, 334, 979, 1152, 1679, and 2776 keV. $\beta$ branches and log ft values have been deduced. The $Q_\beta$ for $^{133}Sb$ has been measured to be 3450 ± 200 keV. The decay scheme is interpreted according to a single-particle shell model. Some $\gamma$ rays have been attributed to $^{133}Sb$, principally one at 1024 keV which is probably the $2^+$ first excited level. (auth)

**18441** GAMMA SPECTRA OF $^{205}Bi$, $^{206}Bi$, $^{203}Bi$, AND $^{204}Bi$. Arl't, R.; Dzhelepov, B. S.; Egorov, Yu. S.; Ivanov, R. B.; Moskvin, L. N.; Kol'nov, Yu. V.; Shtrusnyi, G.; Yakovlev, K. I.; Yanchilenko, G. M. Izv. Akad. Nauk SSSR, Ser. Fiz., 33: 1266-9 (Aug. 1969). (In Russian).

A mixture of bismuth activities was separated from a thorium target irradiated with 660-MeV protons on a synchrocyclotron with the bismuth being selectively extracted from a 0.5N HCl solution by means of TBP. After waiting 7 days $^{205}Bi$ (T = 15 days) and $^{206}Bi$ (T = 6.2 days) were present. On making the separation 2 days after the irradiation it was possible to detect $^{203}Bi$ and $^{204}Bi$. The gamma spectra were measured on a Ge(Li) detector having a sensitive volume of 6.3 $cm^3$ and a resolution of 4 keV at a 1-MeV gamma energy. Relatively large amounts of activity were used to follow the spectra of the hard gamma rays. A lead filter was required to keep from overloading the detector. In the soft region of the spectrum, data were obtained only on the most intense gamma rays. Listings of the gamma rays and relative intensities for these 4 bismuth isotopes are presented. (TTT)

18442 A $^{9}/_{2}^{-}$ ISOMERIC STATE IN $^{123}$Xe. Kerek, A.; Herrlander, C. J.; Luukko, A.; Grecescu, M. (Research Inst. for Physics, Stockholm). Phys. Lett.; 31B: 10-11(5 Jan 1970).

An isomeric state having $T_{\frac{1}{2}} = 6.3 \pm 0.5$ μs has been found in $^{123}$Xe. A spin and parity of $^{9}/_{2}^{-}$ has been assigned to this state. (auth)

18443 BETA BRANCH IN THE DECAY OF $^{143m}$Sm. Felsteiner, J.; Rosner, B. (Technion-Israel Inst. of Tech., Haifa). Phys. Lett.; 31B: 12-13(5 Jan 1970).

The decay of $^{143m}$Sm has been investigated. In addition to the well known 754 keV M4 γ transition, a strongly hindered $\beta^{+}$ branch to $^{143}$Pm has been observed. (auth)

18444 ON THE ELECTRON CAPTURE DECAY OF $^{185}$Os. Schmidt-Ott, W.-D. (Univ., Goettingen, Ger.). Z. Phys.; 232: 393-404(1970). (In German).

The relative probabilities for K-capture $PK_{831}/PK_{646} = 0.109 \pm 0.005$ and $PK_{880}/PK_{646} = 0.708 \pm 0.010$ were measured yielding a total transition energy $Q_{EC} = (1015.0 \pm 0.7)$ keV and $Q_{EC} = (1016 \pm 3)$ keV, rsp. The reported 5-keV transition in the decay of $^{185}$Os between the 880 keV and 875 keV level was not confirmed by comparing the measured relative K-capture probability $PK_{875}/PK_{646} = 0.732 \pm 0.007$ with the calculated value. This is in accord with the measured upper limit for the lifetime of the 880-keV level, $\tau < 3$ nsec. (auth)

## Nuclear Theory

*Refer also to abstracts 17623, 18056, and 18097.*

18445 (ITEF-660) CONCERNING THE BREMSSTRAHLUNG SPECTRUM IN DIRECT NUCLEAR REACTIONS. Kondratyuk, L. A. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Moscow. Institut Teoreticheskoi i Eksperimental'noi Fiziki). 1969. 35p. (In Russian). Dep. CFSTI (U. S. Sales Only).

The possibility of using the bremsstrahlung spectrum in direct nuclear reactions for identification of reaction mechanisms is discussed. The amplitudes of radiative transitions for particles with arbitrary spins in non-relativistic limit are calculated in the soft-photon approximation when only charge radiation of particles and contact radiation in vertices are taken into account. The bremsstrahlung spectrum is calculated for the pole and triangle mechanism and is shown to have appreciable qualitative distinctions in both these cases. Criteria for applicability of the method are derived. (auth)

18446 (ITEF-672) POLAR APPROXIMATION IN INTEGRAL EQUATIONS FOR FOUR PARTICLES. Narodetskii, I. M. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Moscow. Institut Teoreticheskoi i Eksperimental'noi Fiziki). 1969. 24p. (In Russian). Dep. CFSTI (U. S. Sales Only).

The pole approximation in the Faddeev–Yakubowski equations is discussed. This approximation can be applied to four-particle nucleus, consisting of a core plus one nucleon. The equations are derived taking into account the spins and isobaric spins in one case S = T = O. The kernels of this equations contain three-particles one-channel Faddeev functions. The relation of this function with that obtained using the K-harmonic method is discussed. It is shown the equation describing exited states of $^{4}$He consists of experimental magnitudes: the bound state energy and charge formfactor of $^{3}$H when one takes into account the K = O harmonic in the three-particle wave function only. (auth)

18447 TENSOR FORCE ADDITION TO THE MODIFIED SURFACE-DELTA INTERACTION. Manz, J.; Stocker, W. (Univ., Munich). Phys. Lett.; 30B: 631-3(22 Dec 1969).

A potential consisting of the modified surface-delta interaction plus a tensor force is fitted to the 15 empirical two-body matrix elements of the upper s-d shell and, independently, to 12 two-body matrix elements of the $d_{\frac{5}{2}}$-$f_{\frac{7}{2}}$ shells. (auth)

18448 LOW'S THEOREM FOR LOW-ENERGY BREMSSTRAHLUNG IN NEARLY ELASTIC PROJECTILE–NUCLEUS SCATTERING. Dale, Charles; Strobel, George L. (Univ. of Georgia, Athens). Bull. Ga. Acad. Sci.; 27: 169-72(Sep 1969).

Low's theorem for low-energy bremsstrahlung was applied to charged-particle scattering by nuclei. The differential bremsstrahlung cross section for various nuclear scattering processes was calculated using an optical potential and assuming nearly elastic scattering. Preliminary indications are that Low's theorem is valid only when the photon energy is about 1% of the projectile energy. (J.W.R.)

18449 THE INTERNAL BREMSSTRAHLUNG AND THE MECHANISM OF DIRECT NUCLEAR REACTIONS: THE POLE MECHANISM. Janouch, F.; Mach, R. (Nuclear Research Inst., Rez, Czech.). Czech. J. Phys.; 19: 1510-22(1969).

The internal bremsstrahlung (IBS) from direct nuclear reaction is considered. Special attention is paid to the pole diagrams. The suppression effect of the IBS spectra for equal specific charges of all particles participating in the reaction described by the pole mechanism is studied. The importance of the spin term is discussed. The IBS cross-section and its dependence on incident energy for a number of reactions are calculated. The application of the IBS spectrum to identification of the direct reaction mechanism is proposed. (auth)

18450 THEORY OF BETA DECAY. Strachan, C. Selected Readings in Physics. Oxford; Pergamon Press Ltd. (1969). 220p. 40s; $6.25.

Part 1 covers the quantum theoretical background and the original formulation of the interaction Hamiltonian for beta decay as well as recent developments in weak interaction theory. Part 2 consists of 9 original papers on the theory of beta decay published between 1934 and 1957. (J.W.R.)

18451 USES OF THE MAXIMUM LIKELIHOOD METHOD. Weise, L. (Kernforschungsanlage, Juelich, Ger.). Kerntechnik; 11: 662-6(Nov 1969). (In German and English).

As an example, the maximum likelihood method is used for the evaluation of the statistical parameters of a Gaussian normal distribution, then the method is used for the estimation of the half-life of a radioactive sample. Also, a comparison is made between the maximum likelihood method and the method of least squares. (W.H.K.)

18452 NEUTRON-MATTER RADII FROM AN ANALYSIS OF PIONIC ATOMS. Anderson, D. K.; Jenkins, D. A.; Powers, R. J. (Virginia Polytechnic Inst., Blacksburg). Phys. Rev. Lett.; 24: 71-3(12 Jan 1970).

The low-energy pion-nucleus interaction was used as a means for investigating the distribution of nucleons in nuclei. An optical-model analysis of existing experimental data on pionic atoms was used to study possible differences in the rms radii of the neutron and proton densities. The difference in these radii, assumed to be independent of mass number, was found to be $-0.01 \pm 0.16$ F. The absence of any significant difference in these radii should be considered an average behavior for a wide range of nuclei. (auth)

18453 SOFT-CORE MODEL IN NUCLEAR MATTER CALCULATIONS. Kar, R. K.; Roy, M. K. (Univ. of Calcutta). Z. Naturforsch., 24a: 1037-9(July 1969).

Using a Thomas–Fermi method developed by Kumar, LeCouteur, and Roy, it is shown here that the two-body soft-core potential suggested by Köhler and Wagmare does not give rise to correct binding energy and equilibrium density in nuclear matter calculations. (auth)

18454 TIME-DEPENDENT HARTREE–FOCK APPROXIMATION AND THE COLLECTIVE NUCLEAR OSCILLATIONS. Raichev, Pet'r. Izv. Fiz. Inst. Aneb, Bulg. Akad. Nauk.; 19: 155-66(1969). (In Bulgarian).

It is well known that the collective motions of the atomic nucleus may be described with the so called random phase approximation (RPA). The residual interaction in the Hamiltonian of the nuclear system is transformed using Wieck's theorem. That part of the transformed Hamiltonian which coincides with the Hamiltonion of the RPA is considered basic; the other part is considered as a perturbation. Some calculations using simplifications are carried out concerning the Hamiltonian, i.e., the matrix elements of the operator of the residual interaction are considered real and exhibiting additional symmetry. (auth)

18455 ON THE SHELL EFFECT IN (n,2n) REACTION CROSS SECTIONS. Adam, A.; Jeki, L. (Central Research Inst. for Physics, Budapest). Acta Phys. Acad. Sci. Hung.; 26: 335-8 (1969).

Shell effects are investigated by comparing measured (n,2n) cross sections with predictions from a phenomenological equation which is insensitive to threshold energy. The results suggest that only the threshold energy of (n,2n) reaction can be held responsible for any shell effect in the value of the cross section. (auth)

18456 RENORMALIZATION OF FINITE NUCLEAR BRUECKNER THEORY WITH OCCUPATION PROBABILITIES. Becker, Richard L. (Oak Ridge National Lab., Tenn.). Phys. Rev. Lett.; 24: 400-4(23 Feb 1970).

Strong off-diagonal two-nucleon reaction-matrix elements imply appreciable depletion of the normally occupied single-particle

states. Renormalization of the propagators in linked-cluster expansions by factors of occupation probabilities is shown to have important consequences for computed shell-model single-particle energies, separation energies, and spectroscopic factors for nucleon-transfer reactions. (auth)

**18457** INFLUENCE OF NUCLEAR FORCES ON THE COULOMB BARRIER IN HEAVY-ION REACTIONS. Holm, Hartmut; Greiner, Walter (Univ., Frankfurt am Main). Phys. Rev. Lett.; 24: 404-6(23 Feb 1970).

The influence of the Coulomb and nuclear forces on the Coulomb barrier in heavy-ion reactions is studied in a dynamical classical model. It is shown that the fusion barrier is smaller than the conventional Coulomb barrier of two undeformed nuclei. The model yields a dynamical picture of the excitation mechanism of surface variations and giant resonances. It is suggested that—due to nuclear forces—the excitation of the octupole mode is strongly enhanced over the excitation of the quadrupole mode in experiments at the Coulomb barrier. (auth)

**18458** CONFIGURATION MIXING EFFECTS IN MAGNETIC MOMENTS AND IN GAMOW-TELLER MATRIX ELEMENTS OF MIRROR NUCLEI. Leonardi, Renzo (Univ., Bologna); Rosa-Clot, Marco. Phys. Rev. Lett.; 24: 407-10(23 Feb 1970).

Phenomenological analysis of Gamow–Teller transitions and magnetic moments is done for the ground states of the mirror nuclei, putting in evidence the linear quenching of the matrix elements $\langle \Sigma \hat{} \sigma_{3i} \rangle$ and $\langle \Sigma \hat{} \sigma_{3i} \tau_{3i} \rangle$. Configuration mixing techniques in the j-j coupling scheme are discussed and used to explain the quenching and to fit the experimental data. (auth)

**18459** MUTUAL EXCITATION AND REORIENTATION OF TARGET AND PROJECTILE IN COULOMB EXCITATION. Haeusser, O.; Cusson, R. Y. (Atomic Energy of Canada Ltd., Chalk River, Ont.). Can. J. Phys.; 48: 240-3(15 Jan 1970).

In the usual treatment of Coulomb excitation, one of the interacting nuclei is considered as a point charge. It is shown for the special case of E2 excitation how multipoles of both target and projectile can be incorporated in a coupled-channel calculation. It is found that reorientation of the projectile ground state affects the results only if polarized beams are used. (auth)

**18460** GIANT RESONANCES IN HEAVY DEFORMED NUCLEI. Kohr, Charles Byron. College Park, Md.; Univ. of Maryland (1967). 155p.

Thesis.

The unified model and the collective giant dipole resonance model for heavy, deformed odd-A nuclei are unified. The resulting wave functions, energy spectra, and transition probabilities are derived. The predictions of the model are compared to those of the corresponding model for even-even nuclei. It is verified that the main observable features in the photon absorption cross section in the giant dipole resonance region are not influenced by the odd particle, despite the considerably richer spectrum of states as compared to even-even nuclei. As a further expansion of the hydrodynamic model the modes and frequencies of the giant quadrupole resonance of heavy deformed nuclei were calculated. The quadrupole operator is computed and the absorption cross section is derived. The quadrupole sum rule is discussed and the relevant oscillator strengths were evaluated for various orientations of the nucleus. The giant quadrupole resonances have energies at 20 to 25 MeV. The total absorption cross section is about 20 percent of the giant dipole absorption cross section. Of particular interest is the occurrence of the quadrupole mode which is sensitive to the nuclear radius in a direction of approximately $\theta = \frac{1}{4}\pi$ from the symmetry axis. This dependence may give information on the details of the nuclear shape. (Disser. Abstr.)

**18461** UNIFIED INTERPRETATION OF MASS AND CHARGE DISTRIBUTION AND PROMPT NEUTRON EVAPORATION IN LOW-ENERGY NUCLEAR FISSION. Denschlag, H. O.; Qaim, S. M. (Univ., Mainz). Z. Naturforsch.; 24a: 2000-3(Dec 1969).

A simple model for a transition state configuration in low-energy fission is given. In its light the latest experimental data on mass and charge distribution and on prompt neutron evaporation are discussed. (auth)

**18462** ISOTOPIC DEPENDENCE OF PARAMETERS OF OPTICAL POTENTIALS. Dyumin, A. N.; Kaminker, D. M.; Tokarev, B. B. Izv. Akad. Nauk SSSR, Ser. Fiz., 33: 1294-8 (Aug. 1969). (In Russian).

Data on nucleon scattering by atomic nuclei on (p,n) reactions and on an analysis of the binding energy indicate that the isotopic dependence of the real part of the optical potential can be considered as established. An expression is given for the depth of the real part of the nuclear potential for neutrons and protons. The same dependence is assumed for the imaginary part of the potential. Data on the isotopic contribution to the imaginary part are available mainly from experiments on elastic scattering of protons. An attempt is made to analyze other experimental data by analyzing on the basis of an optical potential the available data on the total cross sections of 14.2 MeV neutron interactions. A comparison of the results of the analysis for neutrons and protons is of particular interest, since the corresponding additions in potential have different signs. By treating a large amount of data a value of 58 ± 19 MeV was found for the real part of the optical potential, and a value of 13.5 ± 11.5 MeV for the imaginary part of the potential. Further data on total cross-sections for 14.2 MeV neutrons and for 14.5 MeV protons were examined. An isotopic dependence was found for the imaginary part of the optical potential, but since the real part of the potential was too small, it was concluded that other factors complicating the analysis must exist. (TTT)

**18463** CORIOLIS THEORY OF INTERACTIONS IN THE SUPERFLUID ATOMIC NUCLEI. Birbrair, B. L. Izv. Akad. Nauk SSSR, Ser. Fiz., 33: 1343-6(Aug. 1969). (In Russian).

The effect of superfluidity on the mechanism of interaction between single-particle states and rotation of the nucleus is considered again to make corrections in a previous presentation. It was shown that in a number of cases this effect is substantial. In particular it leads to a change in sign of a coefficient C of an oscillating term in the energy of a rotational band level of the $^{159}$Tb nucleus as compared with the predictions of Nilsson's single-particle model. After correcting the equations, the theoretical value of the coefficient C is compared with the value measured experimentally. Good agreement was obtained between the theoretical value of −9.85 eV and the experimental value of −8.12 eV. (TTT)

**18464** SPECTRA OF PROTONS EMITTED DURING ELECTROSPALLATION OF NUCLEI BY HIGH-ENERGY ELECTRONS. Vysotskii, G. L.; Vysotskaya, A. V. Izv. Akad. Nauk SSSR, Ser. Fiz., 33: 1354-9(Aug. 1969). (In Russian).

Proton spectra are calculated for the (e,e'p) reaction with direct nuclear electrospallation by high-energy electrons. The proton spectra and also the electron spectra in the region of the quasi-elastic maximum are determined by the momenta distributions of nucleons in the nuclear shells. Different variants of moments distributions are discussed, in particular, the effect of diffraction scattering in the final state on these momenta distributions. In addition to the contribution from the radial component of the electromagnetic field, there is in the proton spectra in a region of quasifree kinematics (momentum of recoil nucleus is equal to zero) a second wide maximum arising from electron scattering at large angles. Hence, the longitudinal component of the field is substantial in this case. The contribution of the (e,e'pn) mechanism to the proton spectra is also discussed. (TTT)

**18465** THEORY OF EXCHANGE COLLISIONS. Korolev, A. M. Izv. Akad. Nauk SSSR, Ser. Fiz., 33: 1367-72(Aug. 1969). (In Russian).

A new approach to considering collisions with redistribution of particles is proposed in which the base functions of the initial and final states in the scattering S-matrix, as particular functions of one and the same Hamiltonian, are picked to be orthogonal. Interactions which are the reason for transfer of the system from one state to another do not lead to bound initial and final states. Therefore the base wave functions which simultaneously satisfy two integral equations for a definite state are constructed in such a fashion that in these functions there is simultaneously taken into account the interactions between particles which lead to bound initial and final states. From the orthogonality of these states it is possible to formulate an S-matrix theory for redistribution collisions analogous to the theory of single-particle, potential scattering of Dyson, which is free of the usual difficulties of this theory. As an example, the formal theory of the (d,p) reaction is considered in greater detail. (TTT)

**18466** DAMPING EFFECTS IN THE TRANSMISSION THROUGH THE DOUBLE-HUMPED FISSION BARRIER. Bondorf, J. P. (Univ. of Copenhagen). Phys. Lett.; 31B: 1-4(5 Jan 1970).

An optical model for fission with the double-humped barrier is discussed. A stationary probability current theory for transitions between the class I and class II phases is formulated. The resonating fission cross section is enhanced by the damping width. (auth)

**18467** EFFECTIVE MANY-BODY FORCES IN THE NUCLEAR $1f_{\frac{7}{2}}$ SHELL. Quesne, C. (Univ. Nacional de Mexico, Mexico City). Phys. Lett.; 31B: 7-9(5 Jan 1970).

The method of Talmi for extracting effective two-body interactions from experiment is generalized to include all possible many-body forces compatible with the chosen configurations. It is shown that the interactions of order higher than 2 are important in the $1f_{\frac{7}{2}}$ shell. (auth)

# REACTOR TECHNOLOGY

## Commercial Power Reactors

*Refer also to abstracts 16626, 16757, 16759, 17195, 17210, 17350, 17389, 18752, 18753, and 18761.*

**18468** (AEC-tr-6991) INTEGRATION OF LARGE NUCLEAR POWER PLANTS WITH DESALINATION PLANT. Churin, A. I.; Klyachko, V. A.; Koryakin, Yu. I.; Solov'ev, G. M.; Loginov, A. A.; Rybachev, V. V. Translated from Seventh World Power Conference, Moscow, August 20–24, 1968. 18p. (CONF-680829-1). Dep. CFSTI.

Design requirements for the economic operation of a triple purpose power and process heat reactor in the U.S.S.R. are analyzed. The power and process heat reactor plants would be used for electricity generation, desalination, and industrial heat. (7 references) (D.C.C.)

**18469** (APED-5447) DEPRESSURIZATION PERFORMANCE OF THE GENERAL ELECTRIC BOILING WATER REACTOR HIGH PRESSURE COOLANT INJECTION SYSTEM. Rogers, A. E.; Torbeck, J. E. (General Electric Co., San Jose, Calif. Atomic Power Equipment Dept.). May 1969. 27p. Dep. CFSTI.

The functioning and performance of a high pressure coolant injection (HPCI) system in boiling water power reactors are discussed. The experimental determination of HPCI mixing efficiency is described; detailed data are shown graphically. Results of the analytical evaluation of the HPCI system are discussed. Depressurization test apparatus, results, and procedures are described; data are presented in graphic form. (M.L.S.)

**18470** (BNL-14412) SOME COMPARISONS OF THE ENVIRONMENTAL RISKS FROM NUCLEAR AND FOSSIL FUELED POWER PLANTS. Hull, Andrew P. (Brookhaven National Lab., Upton, N. Y.). [1969]. 17p. Dep. CFSTI.

The costs, in terms of environmental effects, and the benefits from the generation of electricity in nuclear and in fossil fueled power plants are compared. Nuclear plants are found to produce less air pollution than the fossil plants; to present less risk for disaster potential than many accepted large scale technologies; to be capable of controlling radioactivity in their liquid effluents at levels that pose no threat to the environment; and to be capable of managing waste heat without seriously affecting large bodies of water. (16 references) (H.D.R.)

**18471** (BNWL-1169) PACTOLUS: A CODE FOR COMPUTING NUCLEAR POWER COSTS. Bloomster, C. H.; Nail, J. H.; Haffner, D. R. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Jan 1970. Contract AT(45-1)-1830. 202p. Dep. CFSTI.

PACTOLUS is a code for computing nuclear power costs using the discounted cash flow method. The cash flows are generated by PACTOLUS from input unit costs, time schedules, and burnup data. The code is described and the calculations are illustrated. A listing of the code and an example cash flow and power cost calculation for a light water reactor are included. 7 references. (auth)

**18472** (CEA-CONF-1455) FRENCH EXPERIMENTS ON INSTRUMENTATION FOR CONTROL AND OPERATION OF REACTORS IN NUCLEAR POWER STATIONS. Furet, J. (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). [1969]. 79p. (In French). (CONF-691116-1). Dep. CFSTI (U. S. Sales Only).

From IAEA Panel Study on Instrumentation for Control of Nuclear Power Stations, Vienna, Austria.

Details relating to the instrumentation development and use in French fast and thermal power reactors are given. The instruments used in full power operation, control and operation with xenon instabilities are described; in-core instrumentation is discussed. Detector performance for low count-rate areas in the reactor is assessed. Time response, neutron sensitivity, and instrument lifetime are evaluated. Methods for data processing and data display are described; the use of on-line computer systems for data processing is discussed. (28 references) (M.L.S.)

**18473** (DOCKET-50003-19) INDIAN POINT STATION, [UNIT NO. 1]. Survey of Environmental Radioactivity, August 1, 1966–January 31, 1967. (Consolidated Edison Co. of New York, Inc., New York). 20 Feb 1967. 18p. Dep. CFSTI.

**18474** (DOCKET-50003-20) INDIAN POINT STATION, [UNIT NO. 1]. Survey of Environmental Radioactivity, August 1, 1967–January 31, 1968. (Consolidated Edison Co. of New York, Inc., New York). 21 Mar 1968. 7p. Dep. CFSTI.

**18475** (DOCKET-50003-21) INDIAN POINT STATION, [UNIT NO. 1]. Survey of Environmental Radioactivity, February 1–July 31, 1968. (Consolidated Edison Co. of New York, Inc., New York). 21 Aug 1968. 10p. Dep. CFSTI.

**18476** (DOCKET-50003-22) INDIAN POINT STATION, [UNIT NO. 1]. Survey of Environmental Radioactivity, August 1, 1968–January 31, 1969. (Consolidated Edison Co. of New York, Inc., New York). 2 Mar 1970. 22p. Dep. CFSTI.

**18477** (DOCKET-50003-23) [INDIAN POINT STATION, UNITS 1, 2, AND 3]. Ecological Survey of the Hudson River. Progress Report No. 3. (New York Univ., N. Y. Inst. of Environmental Medicine). 30 Sep 1968. 268p. (DOCKET-50247-15; DOCKET-50286-17). Dep. CFSTI.

For Consolidated Edison Co. of New York, Inc., N. Y.

**18478** (DOCKET-50003-24) [INDIAN POINT STATION, UNITS 1, 2, AND 3]. Airborne Infrared Survey [of the] Hudson River, New York. (Texas Instruments Inc., Dallas). Dec 1968. 17p. (DOCKET-50247-16; DOCKET-50286-18). Dep. CFSTI.

For Consolidated Edison Co. of New York, Inc., N. Y.

**18479** (DOCKET-50003-25) [INDIAN POINT STATION, UNITS 1, 2, AND 3]. Model Studies. (Worcester Polytechnic Inst., Mass. Alden Research Labs.). Mar 1969. 49p. (DOCKET-50247-17; DOCKET-50286-19). Dep. CFSTI.

For Consolidated Edison Co. of New York, Inc., N. Y.

**18480** (DOCKET-50029-41) YANKEE NUCLEAR POWER STATION. License No. DPR-3: Technical Specifications, Change No. 74. (Yankee Atomic Electric Co., Boston, Mass.). Sept. 1, 1966. 7p. Dep. CFSTI.

Core loading configuration No. VI for the Yankee Power Reactor is described. Core neutronics and thermal characteristics are given for this configuration. Safety considerations are evaluated. (M.L.S.)

**18481** (DOCKET-50133-27) HUMBOLDT BAY POWER PLANT, UNIT NO. 3. License No. DPR-7: Technical Specifications, Proposed Change No. 28. (Pacific Gas and Electric Co., San Francisco, Calif.). 4 Mar 1970. 5p. Dep. CFSTI.

Proposed modifications to fuel element assemblies for the Humboldt Bay Power Reactor are described. Mechanical design characteristics are tabulated. (M.L.S.)

**18482** (DOCKET-50155-25) [BIG ROCK POINT NUCLEAR PLANT]. [Replacement of Reactor Water Level Sensors]. (Consumers Power Co., Jackson, Mich.). 24 Feb 1970. 4p. Dep. CFSTI.

The replacement of existing water level sensors in the Big Rock Point Power Reactor cooling systems is described. The locations for both the existing level sensors and the replacement level sensors are described; sketches show the location with respect to the pressure vessel and coolant loops. The installation specifications and criteria are listed. (M.L.S.)

**18483** (DOCKET-50171-25) PEACH BOTTOM ATOMIC POWER STATION, UNIT 1. Monthly Operations Report No. 46, December 1969. (Philadelphia Electric Co., Pa.). 25 Feb 1970. 19p. Dep. CFSTI.

**18484** (DOCKET-50206-43) SAN ONOFRE NUCLEAR GENERATING STATION, [UNIT 1]. Semiannual Operating Report No. 5, July 1–December 31, 1969. (Southern California Edison Co., Los Angeles. San Diego Gas and Electric Co., Calif.). 12 Feb 1970. 6p. Dep. CFSTI.

**18485** (DOCKET-50213-32) [CONNECTICUT YANKEE ATOMIC POWER PLANT]. Operational Environmental Radiation Monitoring Program. Summary Report, January–December 1969. (Combustion Engineering, Inc., [Windsor, Conn.] Nuclear Power Dept.). 5 Mar 1970. 23p. Dep. CFSTI.

For Connecticut Yankee Atomic Power Co., Hartford.

**18486** (DOCKET-50244-28) BROOKWOOD NUCLEAR STATION, UNIT NO. 1. First Supplement to Preliminary Facility Description and Safety Analysis Report, [Amendment 1]. (Rochester Gas and Electric Corp., N. Y.). 17 Jan 1966. 227p. Dep. CFSTI.

Name changed later to Robert Emmett Ginna Nuclear Power Plant, Unit 1.

Design parameters are listed. Operating limits are reviewed. Revised physics measurements are included. Emergency core cooling system and containment system requirements are described. Control systems are outlined. Inspection and test schedules are discussed. Accident conditions in the reactor systems are analyzed. (D.C.C.)

**18487** (DOCKET-50245-27) MILLSTONE NUCLEAR POWER STATION, [UNIT 1]. [Preliminary Safety Analysis Report], Amendment 1. (Connecticut Light and Power Co., Hartford. Hartford Electric Light Co., Conn. Western Massachusetts Electric Co., Greenfield). 2 Feb 1966. 103p. Dep. CFSTI.

Information concerning pressure vessel maintenance and inspection procedures is presented. Analysis of the pressure vessel nil ductility transition temperature is included. Design requirements for safety standards are reviewed. Engineered safeguards are described. Containment system design parameters are reviewed. (D.C.C.)

**18488** (DOCKET-50245-28) MILLSTONE NUCLEAR POWER STATION, [UNIT 1]. [Preliminary Safety Analysis Report], Amendment 2. (Connecticut Light and Power Co., Hartford. Hartford Electric Light Co., Conn. Western Massachusetts Electric Co., Greenfield. Millstone Point Co., Wethersfield, Conn.). 23 Feb 1966. 67p. Dep. CFSTI.

Financial data on the owners of the Millstone Point Power Reactor Unit 1 are presented in support of the application for operating license. The 1965 Annual Report for the Connecticut Light and Power Company and the 1965 Annual Report for the Hartford Electric Light Company are included. Nuclear material requirements from 1969 to 1995 are listed. (D.C.C.)

**18489** (DOCKET-50245-29) MILLSTONE NUCLEAR POWER STATION, [UNIT 1]. [Preliminary Safety Analysis Report], Amendment 3. (Connecticut Light and Power Co., Hartford. Hartford Electric Light Co., Conn. Western Massachusetts Electric Co., Greenfield). 7 Mar 1966. 57p. Dep. CFSTI.

Information concerning the bedrock conditions at the reactor site is presented. Emergency core cooling system parameters are reviewed. The use of an isolation condenser system is described. The power conversion system is analyzed. Pressure vessel design specifications are described. Accident analysis for the reactor systems is presented. (D.C.C.)

**18490** (DOCKET-50245-30) MILLSTONE NUCLEAR POWER STATION, [UNIT 1]. [Preliminary Safety Analysis Report], Amendment 4. (Connecticut Light and Power Co., Hartford. Hartford Electric Light Co., Conn. Western Massachusetts Electric Co., Greenfield. Millstone Point Co., Wethersfield, Conn.). 25 Mar 1966. 48p. Dep. CFSTI.

Financial data on the owners of the Millstone Point Power Reactor Unit 1 are presented in support of the application for operating license. The 1965 Annual Report for the Northeast Utilities is included. Nuclear material requirements from 1969 to 1995 are listed. (D.C.C.)

**18491** (DOCKET-50245-31) MILLSTONE NUCLEAR POWER STATION, UNIT 1. [Preliminary Safety Analysis Report], Amendment 7. (Connecticut Light and Power Co., Hartford. Hartford Electric Light Co., Conn. Western Massachusetts Electric Co., Greenfield. Millstone Point Co., Wethersfield, Conn.). Revised Jun 1968. 83p. Dep. CFSTI.

Financial data on the owners of the Millstone Point Power Reactor Unit 1 are presented in support of the application for operating license. The 1967 Annual Report for the Connecticut Light and Power Company is included. (D.C.C.)

**18492** (DOCKET-50247-18) [INDIAN POINT NUCLEAR GENERATING UNIT NO. 2]. [Preliminary Safety Analysis Report], Amendment 15 (Includes Final Facility Description and Safety Analysis Report, Suppl. 6). (Consolidated Edison Co. of New York, Inc., New York). 2 Mar 1970. 439p. Dep. CFSTI.

Reactivity requirements and worths for the Indian Point Power Reactor, Unit 2 are tabulated. Field quality assurance for the control rods is discussed. Stress analyses for primary system support structures are described; results are shown graphically. Transient axial power peaking in the core is discussed; effects of second axial overtones for the xenon oscillations are shown. The fixed in-core instrumentation system is described. Transient operating conditions are discussed with respect to their effects on systems and components over the reactor lifetime. A detailed containment design report and analyses of tornado effects on the containment structure are included. (M.L.S.)

**18493** (DOCKET-50247-20) INDIAN POINT NUCLEAR GENERATING UNIT NO. 2. Preliminary Safety Analysis Report, [Amendment 3]. (Consolidated Edison Co. of New York, Inc., New York). 20 Jun 1966. 25p. Dep. CFSTI.

Methods for attaching the containment vessel liner to the concrete for Indian Point Power Reactor, Unit 2 are described. Analytical techniques for assessing penetration integrity under accident loadings are discussed. Adequacy and reliability of the emergency core cooling system is evaluated. (M.L.S.)

**18494** (DOCKET-50247-21) INDIAN POINT NUCLEAR GENERATING UNIT NO. 2. Preliminary Safety Analysis Report, [Amendment 4]. (Consolidated Edison Co. of New York, Inc., New York). 25 Jul 1966. 26p. Dep. CFSTI.

A detailed analysis of the radiolytic decomposition of water subsequent to a primary piping failure is presented. Equations used to predict the hydrogen yield from the various types of radiation are listed; sample calculations are shown. The seal water system for the containment isolation valves is described. Operation and reliability of the safety injection system is analyzed. (M.L.S.)

**18495** (DOCKET-50247-22) INDIAN POINT NUCLEAR GENERATING UNIT NO. 2. Preliminary Safety Analysis Report, [Amendment 6]. (Consolidated Edison Co. of New York, Inc., New York). 18 Apr 1967. 86p. Dep. CFSTI.

The design of the Emergency Core Cooling Systems (ECCS) for the Indian Point Power Reactor, Unit 2 is detailed; equipment design parameters are tabulated. Results of hypothetical accident calculations and effects of the ECCS operation under accident conditions are evaluated. Effects of maximum coolant loss accidents on the integrity of core and internals are analysed. Design and fabrication techniques and in-service inspection plans are reviewed. (M.L.S.)

**18496** (DOCKET-50247-23) INDIAN POINT NUCLEAR GENERATING UNIT NO. 2. Preliminary Safety Analysis Report, [Amendment 7]. (Consolidated Edison Co. of New York, Inc., New York). 18 Oct 1967. 174p. Dep. CFSTI.

Final design of the safety injection system for the Indian Point Power Reactor, Unit 2 is detailed; design criteria and objectives are described. Effects of blowdown forces and pressures on the core and internals are evaluated. Quality assurance and in-service inspection programs for the cooling systems are outlined. The reactor-pit crucible design is described at length; diagrams and schematics of the crucible are shown. Complete Westinghouse reports on the use of part length absorber rods and burnable poison rods are included. (M.L.S.)

**18497** (DOCKET-50261-24) H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2. [Preliminary Safety Analysis Report], Amendment 18. (Carolina Power and Light Co., Raleigh, N. C.). 27 Feb 1970. 38p. Dep. CFSTI.

The response of reactor vessel intervals of the H. B. Robinson Power Reactor, Unit 2 under blowdown conditions is analysed in detail. A double-ended pipe break is assumed to occur in a few-millisecond time period; structural response is calculated. Hot-leg and cold-leg break analyses are performed for a vertical excitation and for a transverse barrel response. (M.L.S.)

**18498** (DOCKET-50280-24) SURRY POWER STATION, UNITS 1 AND 2. [Preliminary Safety Analysis Report], Amendment 14. (Virginia Electric and Power Co., Richmond). 27 Feb 1970. 333p. (DOCKET-50281-24). Dep. CFSTI.

The complete Technical Specifications for Surry Power Reactor, Units 1 and 2, are presented. Seismic design of the nuclear steam supply system is detailed. Loading conditions and stress limits are listed; design criteria for reactor vessel internals are defined. (M.L.S.)

**18499** (DOCKET-50289-20) THREE MILE ISLAND NUCLEAR STATION, UNIT 1. [Preliminary Safety Analysis Report], Amendment 12 (Includes Final Safety Analysis Report, Vol. 1). (Metropolitan Edison Co., Reading, Pa. Jersey Central Power and Light Co., Morristown, N. J.). 2 Mar 1970. 455p. Dep. CFSTI.

Information on the Three Mile Island Power Reactor, Unit 1 is given on the following broad topics: Site and Environment; Reactor; and Reactor Coolant System. (M.L.S.)

**18500** (DOCKET-50289-21) THREE MILE ISLAND NUCLEAR STATION, UNIT 1. [Preliminary Safety Analysis Report], Amendment 12 (Includes Final Safety Analysis Report, Vol. 2). (Metropolitan Edison Co., Reading, Pa. Jersey Central Power and Light Co., Morristown, N. J.). 2 Mar 1970. 509p. Dep. CFSTI.

The detailed final safety analysis of the containment and other special structures is given. Appendices include: summary of aircraft impact design, report on BBRV post-tensioning systems, and

the report on large opening reinforcements for the reactor building. (M.L.S.)

18501 (DOCKET-50289-22) THREE MILE ISLAND NUCLEAR STATION, UNIT 1. [Preliminary Safety Analysis Report], Amendment 12 (Includes Final Safety Analysis Report, Vol. 3). (Metropolitan Edison Co., Reading, Pa. Jersey Central Power and Light Co., Morristown, N. J.). 2 Mar 1970. 347p. Dep. CFSTI.

Information on the Three Mile Island Power Reactor, Unit 1 is given on the following broad topics: Containment System and Other Special Structures--including stress analyses of buttress and structural integrity testing of containment structure; Engineered Safeguards; Instrumentation and Control; Electrical Systems; and Auxiliary and Emergency Systems. (M.L.S.)

18502 (DOCKET-50289-23) THREE MILE ISLAND NUCLEAR STATION, UNIT 1. [Preliminary Safety Analysis Report], Amendment 12 (Includes Final Safety Analysis Report, Vol. 4). (Metropolitan Edison Co., Reading, Pa. Jersey Central Power and Light Co., Morristown, N. J.). 2 Mar 1970. 281p. Dep. CFSTI.

Information on the Three Mile Island Power Reactor, Unit 1 is given on the following broad topics: Steam and Power Conversion Systems; Radioactive Waste and Radiation Protection; Conduct of Operations; Initial Tests and Operations; and Safety Analysis. (M.L.S.)

18503 (DOCKET-50322-18) SHOREHAM NUCLEAR POWER STATION, UNIT 1. Safety Evaluation. (Division of Reactor Licensing (AEC), Washington, D. C.). 20 Feb 1970. 151p. Dep. CFSTI.

For Long Island Lighting Co., Mineola, N. Y.

The complete safety evaluation of the Shoreham Power Reactor by the USAEC Division of Reactor Licensing is presented. Topics which are considered include: site and environment, facility design, accident analysis, quality assurance, research and development programs, technical qualifications and conduct of operations, emergency planning, conformance with general design criteria, ACRS report, common defense and security, and financial qualifications. (M.L.S.)

18504 (DOCKET-50336-9) MILLSTONE NUCLEAR POWER STATION, UNIT 2. Preliminary Safety Analysis Report, Amendment 5. (Connecticut Light and Power Co., Hartford. Hartford Electric Light Co., Conn. Western Massachusetts Electric Co., Greenfield. Millstone Point Co., Wethersfield, Conn.). 2 Mar 1970. 86p. Dep. CFSTI.

Results of a failure mode and effect analysis of the Millstone Point Power Reactor, Unit 2 secondary system are outlined. Modifications to the enclosure building filtration system are described. Details relating to the liquid radwaste system are given; normal and maximum radioactivity concentrations and quantities of waste at the influent and effluent points are tabulated for the major components; annual concentrations of radionuclides in the effluent are estimated. Missile hazards and protection provisions are listed for the primary systems. Effects of ground water buoyant forces on the auxiliary building base slabs are discussed. Actuation times for the safety injection system are shown. Reliability and performance of transmission lines leaving the switchyard are assessed. Details of component and piping arrangements for the reactor building closed cooling water system are given; diagrams and schematics are included. (M.L.S.)

18505 (DOCKET-50344-7) [TROJAN NUCLEAR PLANT]. Preliminary Safety Analysis Report, Amendment 4. (Portland General Electric Co., Oreg.). 26 Feb 1970. 232p. Dep. CFSTI.

A description of the on-site atmospheric monitoring system for the Trojan Power Reactor, Unit 1 is given; the general environmental radiation monitoring plan is detailed. In-service inspection and testing of the pressure vessel are outlined. The quality control plan for welding in the cooling system is described. Component and system testing schedules are tabulated. General design criteria are discussed. Revised and additional pages are included for the SAR. (M.L.S.)

18506 (DOCKET-50346-6) DAVIS-BESSE NUCLEAR POWER STATION. Preliminary Safety Analysis Report, Amendment 2. (Toledo Edison Co., Ohio). 20 Feb 1970. 181p. Dep. CFSTI.

Selection of the maximum probable and maximum possible earthquakes for the Davis-Besse Power Reactor site is discussed; recommended response spectra are shown. Heat transfer calculations for thermal and hydraulic design are discussed. Revised design data for the reactor coolant pumps are tabulated. (M.L.S.)

18507 (FRIGG-PM-15) FT-36b: RESULTS OF VOID MEASUREMENTS. Skaug, J. A.; Eklund, R.; Nylund, O. (Danish Atomic Energy Commission, Risoe. Research Establishment). 5 Sep 1968. 48p. Dep. CFSTI (U. S. Sales Only).

The experimental results of void measurements at 30, 50, 70 and 87 bars on the Marviken test element FT-36b are given. Complete tables of radial and axial void are included. Measurements near the exit of the test section had to be excluded because of a necessary change of the paths of power supply cables. Some high quality data were thus lost. A relatively detailed procedure is given and a section on possible errors is included. Most of the data have been plotted and curves are included for comparing different conditions. Some of these curves are based on a weak statistical basis and should be weighted accordingly. Compared to the results of the previous test section FT-36a, there are noticeable differences in the slip conditions which are not readily accounted for. (7 references) (auth)

18508 (FRIGG-PM-39) USE OF THE THERMOHYDRAULIC SUBCHANNEL PROGRAMME HAMBO ON THE TEST ELEMENTS FT 36a AND FT 36b. PART I. THE LOCAL VOID DISTRIBUTION. Cortzen, Frank W. (Danish Atomic Energy Commission, Risoe. Research Establishment). Feb 1969. 81p. (FRIGG-Note-R-39; RISO-M-869). Dep. CFSTI (U. S. Sales Only).

The thermohydraulic subchannel program HAMBO has been used to calculate the local void in circular subchannels of the FRIGG-FT 36a and FT 36b-test elements, which simulate the Marviken heavy water 36-rod fuel elements. The mean behavior of the void distribution for both elements are for high massflows simulated, within 3%, by a scaling of the parameter, K, in the Bankoff-Jones void-correlation. This scaling is mass-flow-dependent for low mass flows. The distribution of void between the subchannels is regulated by the common mixing scaling parameter, Fm, which refers to the nominal mixing model in HAMBO. This mixing model is derived from the subchannel mean turbulency. For FT 36a (no radial heatflux-distribution), the mixing factor Fm is 3 to 4, for FT 36b (radial heat flux distribution), Fm is 2 to 3. The simulation is tolerable for the two outermost subchannels, whereas the void contents in the two innermost subchannels are not so well experimentally determined that definitive conclusions can be drawn. A local formulation of the void correlations can be important for the fitting of the mixing. Inlet flow distribution between subchannels does not affect the fitting of void and mixing in the calculations. 22 references. (auth)

18509 (NP-18089) ECONOMICS OF SEAWATER DESALTING IN COMBINATION WITH AMMONIA AND POWER PRODUCTION. Research and Development Progress Report No. 458. Bresler, Sidney A. (Bresler Chemical Engineering Associates, New York). Aug 1969. Contract 14-01-0001-1485. 145p. GPO $3.00.

Includes Annex A by S. J. Senatore, Oak Ridge Gaseous Diffusion Plant, Tenn.

The feasibility of lowering the operating cost of producing desalted water by combining its production with that of ammonia and electricity is analyzed. (2 references) (D.C.C.)

18510 (TID-25365) MONTHLY REPORT FOR THE GUNDREMMINGEN NUCLEAR POWER PLANT, JANUARY 1970. (Kernkraftwerk RWE-Bayernwerk G.m.b.H., Gundremmingen (West Germany)). 16 Feb 1970. 45p. (In German). Dep. CFSTI.

Operations and maintenance requirements during January 1970 are described. Personnel radiation exposures during the month are listed. Radiation monitoring measurements are presented. (D.C.C.)

18511 (WCAP-3017-6091) YANKEE CORE EVALUATION PROGRAM. Quarterly Progress Report for the Period Ending September 30, 1969. (Westinghouse Electric Corp., Pittsburgh, Pa. Atomic Power Div.). Contract AT(30-1)-3017. 34p. Dep. CFSTI.

The first phase of post-irradiation examination and testing of Yankee Core V Zircaloy-clad $UO_2$ fuel rods was completed. Principal findings are summarized as follows: (1) Irradiation-induced increases in fuel rod length generally fit the pattern of fast neutron fluence dependence of published data. However, the range of fast fluence for the Yankee fuel rods is too small to determine a specific correlation of the Yankee rod length changes. (2) Tensile properties of the Zircaloy clad were independent of fast neutron fluence and test temperature between 625°F and 675°F. The tensile properties were generally consistent with data in the literature. (3) There was no clear correlation between regular burst behavior of Zircaloy and test temperature between 625°F and 675°F. (4) Experimentally determined dynamic burst test failure temperatures for irradiated Zircaloy were between 100°F and 300°F lower than

predicted. Quench tests of irradiated Zircaloy clad revealed no spalling or cracking under thermal shock conditions. (5) Continued evaluation of fuel burnup data has reduced, but not eliminated, the discrepancies between results based on heavy element (U and Pu) isotopic measurements and those based on $^{148}Nd$ production. (auth)

**18512** (ZJE-60) A BRIEF DESCRIPTION OF PURPOSE AND FUNCTION OF FUELLING MACHINES IN A-1 NUCLEAR POWER STATION. Lerach, J.; Pohorelicky, A. (Skoda Concern, Pilsen (Czechoslovakia). Nuclear Power Plants Div.). Nov 1969. 19p. (In Russian). Dep. CFSTI (U. S. Sales Only).

**18513** NO ORDINARY POWER STATION. Jeffs, E. Engineering; 209: 153-4(Feb 1970).

Novel features of construction of the Hartlepool AGR station, designed for a modular boiler system, include the erection of six concrete towers as the basis of the main structure, which will itself be used as a constructional aid, and the use of wire-winding prestressing techniques for the pressure vessel. (UK)

**18514** THE BIBLIS PLANT NEAR WORMS. Com. Naz. Energ. Nucl., Notiz.; 15: No. 12, 97-9(Dec 1969). (In Italian).

The Biblis (KKB) Plant, which constitutes the latest development of the Obrigheim and Stade PWR power plants, is described. (auth)

**18515** CUSTOM-TAILORED NUCLEAR TRAINING. Hancock, John A. Power Eng.; 74: No. 2, 31-5(Feb 1970).

The training program employed by the Florida Power Corporation to instruct personnel in the planning, construction, operation, and maintenance of the Hutchinson Island nuclear power plant is described. Formal nuclear training courses are outlined, and the schedule for academic and observation training of management and operating personnel is tabulated. (H.D.R.)

**18516** NINE MILE POINT'S RADIOCHEMICAL LABORATORY. Bowers, R. R. Power Eng.; 74: No. 2, 43-5(Feb 1970).

Radiation protection and contamination samples are handled in the Nine Mile Point radiochemical laboratory. Radiation and contamination control design features are discussed, and the design of counting rooms, hoods, and the low-level and high-level labs is described. (H.D.R.)

**18517** MEASUREMENT OF STEAM PURITY IN THE GUNDREMMINGEN NUCLEAR POWER PLANT. Schroeder, H. J. (Kernkraftwerk RWE-Bayernwerk GmbH, Gundremmingen, Ger.); Schermann, W.; Class, G. pp 11-15 of VGB-Speisewassertagung 1967. Essen; VGB-Dampftechnik GmbH (1967). (In German).

From VGB Feedwater Conference, Essen, Germany. See CONF-671090.

In boiling water reactors, the steam is contaminated with radioactive substances. The water content also has to be considered because of corrosion and loss of turbine efficiency. Assessment of radioactive contamination plays a major role during shutdowns for repair. To measure the purity of steam and its water content, $^{24}Na$ was chosen as indicator for the primary circuit, calcium was selected and determined by flame spectroscopy. Methods of sampling as well as results of measurements are presented. (H.B.G.)

**18518** SOME THOUGHTS ON THE NUCLEAR AGRO-INDUSTRIAL COMPLEX. Shen-Miller, J. (Argonne National Lab., Ill.). Bioscience; 20: 98-100(15 Jan 1970).

**18519** POWER REACTORS 1970. Nucl. Eng. Int.; 15: 111-34(Feb 1970).

A listing of all known power projects is presented. Tabular data include general information including costs, contractors, owners etc; technical parameters; progress schedules; and a list of planned reactors. Approximate locations are illustrated. (UK)

**18520** PROCEEDINGS OF THE AMERICAN POWER CONFERENCE, CHICAGO, ILLINOIS, APRIL 22-24, 1969. VOLUME 31. Chicago; American Power Conference (1969). 1087p. $15.00. (CONF-690439).

Separate abstracts are prepared for the 28 papers which relate to nuclear power plants, nuclear generation capability and availability, nuclear power plant economics, and personnel training for nuclear facilities. In addition to the above, the Proceedings also contain papers on Mechanical Sessions; Industrial Sessions; Water Technology Sessions; Hydroelectric Sessions; and Electrical Sessions. (M.L.S.)

*For abstracts of individual papers see: 18521–18537, 18593–18597, 18641–18643, 18659, 18681, and 18689.*

**18521** IMPACT OF CHANGING ECONOMICS ON ELECTRIC UTILITIES. Stanley, C. Maxwell (Stanley Consultants, Muscatine, Iowa). Proc. Amer. Power Conf.; 31: 7-16(1969).

From American Power Conference, Chicago, Ill. See CONF-690439.

Effects of economic changes on electricity production costs in the U. S. are considered. Trends of construction costs, costs of money, and transmission are assessed. Nuclear and coal fired plant costs are tabulated by unit size as of January 1969. Corporate structure and system planning are considered. (10 references) (M.L.S.)

**18522** OUTLOOK FOR FAST BREEDERS: INDUSTRY'S VIEW. Behnke, W. B. Jr. (Commonwealth Edison Co., Chicago); Landis, John W.; Dietrich, J. R.; Flaherty, J. J.; Rengel, J. C.; Rowand, W. H.; Schubert, A. E. Proc. Amer. Power Conf.; 31: 60-76(1969).

From American Power Conference, Chicago, Ill. See CONF-690439.

The practical application of the fast breeder reactor to commercial power production is discussed. The panel discussion, chaired by W. B. Behnke, presents the fast breeder development from the points of view of: John W. Landis, Gulf General Atomic; J. R. Dietrich, Combustion Engineering; J. J. Flaherty, Atomics International; J. C. Rengel, Westinghouse; W. H. Rowand, Babcock and Wilcox; A. E. Schubert, General Electric. (M.L.S.)

**18523** OPERATOR LICENSING AND NUCLEAR PLANT SIMULATORS. Kelly, Frank L.; Skovholt, Donald J.; Morris, Peter A. (Atomic Energy Commission, Washington, D. C.). Proc. Amer. Power Conf.; 31: 77-83(1969).

From American Power Conference, Chicago, Ill. See CONF-690439.

Statutory requirements of the AEC with regard to reactor-operator licensing are summarized. Eligibility of license applicants and the use of nuclear plant simulators for operator training are discussed. Requirements for license renewal are described. Effects of AEC Division of Reactor Licensing workload on processing of applications and administration of operator examinations are considered. (M.L.S.)

**18524** WESTINGHOUSE NUCLEAR TRAINING CENTER AT ZION, ILLINOIS. Schuman, S. D. (Westinghouse Electric Corp., Pittsburgh). Proc. Amer. Power Conf.; 31: 84-9(1969).

From American Power Conference, Chicago, Ill. See CONF-690439.

The plans for the Westinghouse pressurized water reactor (PWR) training center, to be built near Commonwealth Edison's Zion plant, are described. The training sessions to be offered at the center are described. The PWR simulator, around which the training center is built, is described. (M.L.S.)

**18525** SIMULATOR TRAINING OF NUCLEAR POWER PLANT OPERATORS. Deddens, J. C. (Babcock and Wilcox, Lynchburg, Va.). Proc. Amer. Power Conf.; 31: 90-8(1969).

From American Power Conference, Chicago, Ill. See CONF-690439.

The pressurized-water power-reactor-oriented training programs offered by Babcock and Wilcox for utilities personnel are outlined. The PWR simulator used in the training program is described. Economic and technical advantages of simulator training are considered. (M.L.S.)

**18526** EXPERIENCE IN THE USE OF A BWR NUCLEAR POWER PLANT TRAINING SIMULATOR. Gridley, R. L. (General Electric Co., Morris, Ill.); Guppy, W. H.; Perkins, K. T. Proc. Amer. Power Conf.; 31: 99-103(1969).

From American Power Conference, Chicago, Ill. See CONF-690439.

The boiling water reactor (BWR) training center, established by General Electric, is described. Experience gained in the training of BWR power plant personnel is summarized. Program objectives are outlined. (M.L.S.)

**18527** OPERATING FLEXIBILITY THROUGH IN-CORE FUEL MANAGEMENT. Cahn, H. (Combustion Engineering Inc., Windsor, Conn.); Knapp, R. W.; Grube, R. M.; Hinkle, W. D. Proc. Amer. Power Conf.; 31: 155-63(1969).

From American Power Conference, Chicago, Ill. See CONF-690439.

Optimization of in-core fuel management is discussed. Basic goals, toward which the optimization is directed, are defined. Factors which affect refueling shutdowns are considered. A basic fuel management scheme is described for a PWR. Effects of core-power distributions on fuel management are discussed. The analytical methods used for power distribution, and depletion

calculations are outlined; assumptions made in the analytical methods are listed. Variations from the base management scheme are considered; power costs are compared. (M.L.S.)

18528 CORE MANAGEMENT AND FUEL-CYCLE COSTS. Bauhs, D. J.; Leggett III, W. D.; Nordman, D. A. (Westinghouse Electric Corp., Pittsburgh). Proc. Amer. Power Conf.; 31: 164-73(1969).

From American Power Conference, Chicago, Ill. See CONF-690439.

Design and long range planning for fuel cycle management in pressurized water reactors are discussed. Factors which affect in-core management and core reloading are evaluated. Plant capacity factors and multiple nuclear units are discussed from an economic standpoint. Possibilities of fuel element reinsertion and subsequent economic effects are considered. (M.L.S.)

18529 UTILITY-SUPPLIER COOPERATION IN FUEL MANAGEMENT. Tribble, James E. (Yankee Atomic Electric Co., Boston); Bigge, William B. Proc. Amer. Power Conf.; 31: 174-9(1969).

From American Power Conference, Chicago, Ill. See CONF-690439.

The relationship between the fuel supplier and utility management with regards to fuel management is discussed. Responsibilities for each step in the fuel cycle are outlined. (M.L.S.)

18530 DESIGN CRITERIA FOR NUCLEAR POWER PLANTS. Fischer, Joseph A.; Murphy, William J. (Dames and Moore, New York). Proc. Amer. Power Conf.; 31: 200-9(1969).

From American Power Conference, Chicago, Ill. See CONF-690439.

The requirements for establishing seismic design criteria for nuclear power plants are described. The concepts of the operating basis earthquake and the design basis earthquake are discussed; methods for selecting these concepts are outlined. Seismic and tectonic histories and their roles in site selection are discussed. (9 references) (M.L.S.)

18531 EFFECT OF EARTHQUAKE CRITERIA ON NUCLEAR PLANT DESIGN. Bergstrom, R. N.; Chu, S. L.; McLaughlin, J. M.; Small, R. J. (Sargent and Lundy, Chicago). Proc. Amer. Power Conf.; 31: 210-21(1969).

From American Power Conference, Chicago, Ill. See CONF-690439.

Seismic design criteria and their applications to Class I, Class II, and Class III systems and structures in nuclear power plants are discussed. Methods for dynamic analyses of earthquake loadings are described. (M.L.S.)

18532 AN APPLICATION OF CORPORATE MODELS IN GENERATION PLANNING. McNelly, M. J. (General Electric Co., San Jose, Calif.); Thompson, R. L.; Wood, A. J. Proc. Amer. Power Conf.; 31: 458-67(1969).

From American Power Conference, Chicago, Ill. See CONF-690439.

A corporate utility model, developed by Boston Edison and General Electric, is described; a flow diagram illustrates the phases of the model. The incorporation of nuclear units into the electrical production system is discussed. Computer program links to the corporate model which simulate nuclear fuel management are described. Expenditure patterns for a ficticious, typical investor-owned utility are calculated; data are presented in both tabulator and graphic form. Fossil-unit data and the alternatives of nuclear power and power pool operations are analyzed from an economics point-of-view. Nuclear fuel options and their effects on the economics of utility operation are evaluated. (M.L.S.)

18533 COOLING WATER REQUIREMENTS FOR THE GROWING THERMAL GENERATION ADDITIONS OF THE ELECTRIC UTILITY INDUSTRY. Hauser, L. G. (Westinghouse Electric Corp., East Pittsburgh). Proc. Amer. Power Conf.; 31: 477-83(1969).

From American Power Conference, Chicago, Ill. See CONF-690439.

Long-range effects of thermal discharge into the environment are considered in relation to the forecast growth of electricity production. Types of energy sources for the generation of nuclear power are discussed. Heat rejection is shown graphically as a function of type of energy source. Methods of heat dissipation other than direct cooling water rejection are outlined; cost additions are tabulated and evaluated for each method. (M.L.S.)

18534 PROGRESS IN MOISTURE SEPARATOR-REHEATERS FOR NUCLEAR POWER PLANTS. Lemezis, S.; Bushey, J. R.; Rabas, T. J. (Westinghouse Electric Corp., Philadelphia). Proc. Amer. Power Conf.; 31: 484-93(1969).

From American Power Conference, Chicago, Ill. See CONF-690439.

The needs for moisture separation and reheat in BWR's and PWR's are summarized. The design of a moisture separator-reheater is described; materials of construction and overall arrangement are considered. Operating experience with moisture separator-reheaters is summarized. (12 references) (M.L.S.)

18535 THE NEED FOR ADVANCE PLANNING OF THERMAL DISCHARGES BEFORE SITE ACQUISITION. Jaske, R. T. (Battelle Memorial Inst., Richland, Wash.). Proc. Amer. Power Conf.; 31: 733-42(1969).

From American Power Conference, Chicago, Ill. See CONF-690439.

Alternate courses of action which are open to the utilities for handling of thermal discharges from power plants are discussed. Factors which affect planning for treatment of thermal discharges are considered. Effects of water movement and mixing zones are evaluated with respect to heat dissipation. Biological effects and the control of environmental conditions are summarized. Results of thermal modification of the Illinois Waterway are discussed. (8 references) (M.L.S.)

18536 COORDINATION OF LARGE NUCLEAR POWER PLANTS WITH PACIFIC NORTHWEST HYDRO SYSTEM. Starr, E. C.; Tallman, R. J.; Fuller, N. E.; Huffman, W. B. (Bonneville Power Administration, Portland, Oreg.). Proc. Amer. Power Conf.; 31: 773-80(1969).

From American Power Conference, Chicago, Ill. See CONF-690439.

The use of large nuclear plants in conjunction with the hydro plants in the Pacific Northwest power system is described. Planned energy resources are shown through 1990. Predicted annual capacity factors and assumed thermal generation installation schedules for the Pacific Northwest are tabulated. (M.L.S.)

18537 A STUDY OF HYDRO AVAILABILITY AS IT AFFECTS OPERATION OF THERMAL GENERATION IN THE NORTHWEST. Houser, Hugh G. (Westinghouse Electric Corp., East Pittsburgh). Proc. Amer. Power Conf.; 31: 781-5(1969).

From American Power Conference, Chicago, Ill. See CONF-690439.

The surplus energy available in the Pacific Northwest hydro system is evaluated in relation to the plant capacity factors for nuclear plants. Installation schedules are given for nuclear units; nuclear plant projected use factors are also tabulated. (M.L.S.)

18538 THE SYSTEM FOR A SEISMIC SURVEY OF THE GARIGLIANO NUCLEAR POWER PLANT. Foti, Guido. Ing. Nucl.; 10: No. 5, 25-31(Sep-Oct 1969). (In Italian).

The methods used in the seismic evaluation of the Garigliano Power Reactor are discussed. The testing methods used at the Garigliano site are described. The instrumentation used in the testing is discussed; block diagrams are shown. (M.L.S.)

18539 NUCLEAR POWER PLANTS. Dollezhal, N. A. Energ. Atomtech.; 21: 623-32(Nov-Dec 1968). (In Hungarian).

Economic aspects, technology, and efficiency of reactor power plants are discussed, and perspectives of using nuclear power in all phases of industry are analyzed. (R.V.J.)

18540 OUTLOOK FOR NUCLEAR POWER-STATION CAPITAL COSTS. Steigelmann, William (Franklin Inst. Research Labs., Philadelphia). Reactor Technol.; 13: 14-17(Winter 1969-70).

Trends in the predicted costs of nuclear power plants for the next 20 years are examined. The basis for deriving a relation for predicting the cost of a standard plant is obtained from an analysis of capital cost data for 40 U. S. plants larger than 800 MW(e). An adjustment factor pertaining to a standardized plant and an escalation factor accounting for higher construction and money costs are derived for use in capital cost estimates. 7 references. (H.D.R.)

18541 ROLE OF NUCLEAR POWER PLANTS IN HUNGARY. Gyoergy, Vajda; Tibor, Laczai Szabo. Energ. Atomtech.; 22: 313-21(Jul 1969). (In Hungarian).

The economics of nuclear power plants in small countries is examined. The influence of political and technological factors on power plant development is discussed. The Hungarian nuclear power plant program is described, and the effects of financing, fuel costs, operating costs, and other factors on economic calculations are analyzed. (auth)

18542 PRESENT DEVELOPMENT OF NUCLEAR POWER PLANTS. Leval, Andras. Energ. Atomtech.; 22: 322-30(Jul 1969). (In Hungarian).

Technology and aspects of development of nuclear power plants are discussed. Characteristic features of breeder reactors are analyzed and the efficiency and economics of various types of reactors are compared. (R.V.J.)

18543 PROBLEMS RELATED TO THE OPERATION OF THE FIRST HUNGARIAN NUCLEAR POWER STATION. Ocsai, Mihaly. Energ. Atomtech.; 22: 339-51(Jul 1969). (In Hungarian).

Technological data and economics of the first nuclear power plant designed for operation in Hungary are discussed. Aspects of nuclear safety, efficiency, and construction pertinent to the local conditions are analyzed. (R.V.J.)

18544 THE LINGEN NUCLEAR POWER STATION. Deublein, Otmar (Kernkraftwerk Lingen GmbH, Lingen-Ems, Ger.). Elektrotech. Z.; A90: 492-4(26 Sep 1969). (In German).

Technical data and illustrations are provided of the nuclear power station situated on the Dortmund–Ems Canal 6 km from the center of the city of Lingen in the German Federal Republic. The Lingen nuclear power station has a gross electrical capacity of 252 MW. It is fitted with a boiling-water reactor with once-through cooling. The steam produced in the reactor is fed to heat exchangers in which secondary steam is generated. This is superheated in an oil-fired superheater to 530°C and then fed to the turbine. The Lingen nuclear power station was constructed in 48 months and was taken over by the operator on October 1968. During the period it has been in operation the operational results show an availability of 96%. Only 2 shutdowns were experienced, and lasting for only a few hours. Malfunctions in the electrical or the measurement-regulatory systems were the cause of the shutdowns. Detailed specifications of the reactor are tabulated. (BBB)

18545 THE STADE NUCLEAR POWER STATION. Mueller, Herbert; Stahlschmidt, Heinz (Siemens AG, Erlangen, Ger.). Elektrotech. Z.; A90: 505-9(26 Sep 1969). (In German).

An illustrated description is given of the nuclear power plant having a 660-MW(e) capacity being constructed 35 miles west of Hamburg in the German Federal Republic. The Stade nuclear power station is one of the first installations by which competitively economic electricity generation will be achieved from nuclear energy. Following a description of the design features of the plant, the advances achieved in the construction of power stations with pressurized-water reactors are reviewed. Burnup and thermal efficiency improvements are the main features. The considerable innovations in the design and construction of reactor pressure vessels, steam generators and primary coolant pumps, as well as in plant layout in the annular space in the reactor building, are presented. The state of progress on the site in July 1969, where the second stage of erection of the steel shell was begun, is described. The specifications of the Stade and the Obrigheim power plants are given in detail and compared. (BBB)

18546 ECONOMICALLY EFFECTIVE ATOMIC POWER SYSTEM. Hulka, Ivan; Komarek, Arnost. Skoda Rev.; No. 6, 4-9 (1968).

Criteria affecting the economics of nuclear power stations are examined with particular emphasis on the fuel cycle. An analysis of nuclear power economics is carried out on a model of the Czechoslovakian utility system. (H.D.R.)

18547 SOME ENVIRONMENTAL FACTORS TO BE CONSIDERED IN THE DESIGN OF THERMAL POWER PLANTS IN THE NORTHWEST. Salo, Ernest O. (Univ. of Washington, Seattle). Trend. Eng. Univ. Wash.; 21: 3-7; 32(Oct 1969).

Some environmental factors, such as thermal and radioactive pollution, that must be taken into account in the site selection and design of nuclear and fossil-fueled power stations are considered. Concern is being expressed over the discharge of large volumes of heated water into the relatively clean and cool waters of Puget Sound and the possibility of the introduction of low-level radiation into the water and air. A thermal plant, whether nuclear- or fossil-fueled, can affect the marine biota and the marine environment by removing large quantities of water for condenser cooling, and by passing this water through a pumping and screening system, by elevating its temperature, by adding chlorine compounds to control the growth of marine-fouling organisms, and by discharging the water in an area different from that of the intake and thus causing changes in the current patterns. If it is a nuclear-powered unit, it also adds low-level radioactive wastes to the coolant waters. The problems to be considered by the designer include the biological and environmental processes that may be changed by these procedures, the size of the area to be affected, and proper control of procedures by plant design. Some thermal stations are operating without appreciable (if any) detrimental effect upon the environment. Other plants could operate more efficiently with greater allowable limits of thermal and radioactive discharge, thus producing power at a lower cost. The discharge of radioactive wastes is under the jurisdiction of the AEC as well as the state agencies. When the present standards are met, the maximum concentration that a human would derive from a protein diet derived from seafoods maintained in the discharge waters would be well within the maximum permissible body burden. The standards set take into consideration the proclivities of marine organisms to concentrate certain nuclides. (BBB)

18548 THE ATUCHA NUCLEAR POWER STATION. Hirmer, Guenter; Seifert, Werner (Siemens AG, Erlangen, Ger.). Elektrotech. Z.; A90: 509-13(26 Sep 1969). (In German).

A description is given of the nuclear power plant being built at Atucha (100 km northwest of Buenos Aires) for the Argentine Comision Nacional de Energia Atomica by Siemens AG. It was begun in May 1968 and after a 4-yr construction period will be in operation by the middle of 1972. For generating heat in the Atucha station there is a pressurized water reactor with natural U as the fuel; for moderation and cooling of the reactor core, heavy water is used. The electrical net capacity is 319 MW. The nuclear reactor is a further development of the multi-purpose research reactor (MZFR) designed and built by Siemens, which is a 50-MW nuclear power station in Karlsruhe. Since the $D_2O$ and the $H_2O$ pressurized water reactors which have been built are very similar technologically, the experience and data obtained with the high-capacity $H_2O$ pressure reactors can be applied in full for the Atucha station. The reactor installation and the special features are compared with $H_2O$ pressurized water reactor features. Diagrams are provided of the containment vessels, reactor core and arrangement of fuel elements, and electrical circuitry. (BBB)

18549 THE WUERGASSEN NUCLEAR POWER STATION. Vennemann, Josef (Kraftwerk-Union AG, Frankfurt am Main). Elektrotech. Z.; A90: 501-4(26 Sep 1969). (In German).

A description is given of 640-MW power reactor which is now being built at Wuergassen on the Weser River for the Preussische Elektrizitaets-AG. The power station will be provided with a boiling-water reactor. The order for the complete installation, including the provision of the first supply of fuel, was awarded to the Allgemeine Elektrizitaets-Gesellschaft AEG-Telefunken. Construction work was commenced in January 1968 and the shell of the building for the power station block unit has been completed. After a construction period of 4 yr the Wuergassen nuclear power station will commence power generation at the beginning of 1972. Specifications of the plant and its reactors are given in detail and include a maximum electrical capacity of 670 MW, thermal capacity of 1912 MW, saturated steam production of 3507 t/hr at 285°C and $p = 695$ N/cm$^2$. The 86 t of U fuel is distributed in 444 fuel elements, arranged quadratically. The mean enrichment of the fuel is 2.6%. (BBB)

18550 OBRIGHEIM NUCLEAR POWER STATION. Schenk, Herbert (Kernkraftwerk Obrigheim GmbH, Obrigheim, Ger.). Elektrotech. Z.; A90: 495-501(26 Sep 1969). (In German).

Along with the reactors at Gundremmingen and Lingen, the Obrigheim nuclear power station is one of the 3 demonstration nuclear power stations in the Federal Republic. The station, which was constructed in 4 yr by Siemens as the general contractor, was taken over by the Kernkraftwerk Obrigheim GmbH on 31 March, 1969. It has a pressurized water reactor and has a guaranteed electrical net capacity of 282.7 MW. The corresponding heat output of the reactor is 907.5 MW. By using this heat 1706 t of saturated steam at 262°C and $p = 490$ N/cm$^2$ are produced per hour in 2 steam generators. A 300-MW condensation turboset running at 3000 rpm is used for electricity generation. Up to the end of July 1969 about 1 tWh was produced by the installation which was running on basic load. Detailed diagrams are presented which show the general reactor design and containment vessel structure, fuel element arrangement, heat and coolant circuits, and the electrical circuitry. (BBB)

18551 THE RWE–BAYERNWERK GUNDREMMINGEN (KRB) NUCLEAR POWER STATION. Weckesser, August (Kernkraftwerk RWE-Bayernwerk GmbH, Gundremmingen, Ger.). Elektrotech. Z.; A90: 488-92(26 Sep 1969). (In German).

The Gundremmingen power reactor, which will have a net electrical capacity of 237 MW, is described and illustrated. Among the series of West Germany-developed light-water cooled reactors the Gundremmingen installation represents the boiling-water type. The advantage of direct steam generation in the core makes it possible to operate the turbine without the interposition of a heat exchanger. The construction of the whole installation is therefore

characterized by simplicity. In accordance with the state of technique in the year 1962, the installation was provided in addition with a secondary steam circuit, which makes possible a higher power density of the core and gives the reactor favorable automatic regulation in the upper load range. The fuel will have an average enrichment of 2.24% $UO_2$ in Zircaloy tubes having an outer diameter of 14.29 mm. Arrangement of the rods in the core is diagramed, and detailed specifications of the reactor are tabulated. (BBB)

**18552** ELECTRICAL GENERATION FROM NUCLEAR POWER PLANTS IN THE WORLD IN 1969. Atomwirt., Atomtech.; 15: 100(Feb 1970). (In German).

Statistics on the 1969 production of electricity from nuclear power plants is tabulated for the western world. Total MWh generation is listed by country according to specific reactors. (M.L.S.)

**18553** REALIZATION OF THE VANDELLOS NUCLEAR POWER PLANT. Buttin, M. Jean. Bull. Inform. A.T.E.N. (Asst. Tech. Energ. Nucl.), No. 77, 38-41(May-June 1969). (In French).

The Vandellos nuclear power plant, now under construction on the Mediterranean coast, is in the natural U–graphite–$CO_2$ chain of the integrated type with heat exchanger and reactor core included in a prestressed concrete vessel. The vessel is described in some detail. The construction of the reactor and its progress are discussed. (J.S.R.)

**18554** RELATIONSHIP BETWEEN NUCLEAR FUEL AND REACTOR POLICIES IN WESTERN EUROPE. Saeland, E. pp 65-76 of Utilizzazione del Combustibile Nucleare. Roma; Comitato Nazionale Energia Nucleare (1969).

From 10th International Nuclear Energy Conference, Milan, Italy. See CONF-681219.

The present energy situation in Europe and expected short-term developments, the interpreting of the probable role of nuclear energy in these developments in terms of nuclear fuel supplies and fabrication, enrichment and reprocessing facilities are described. Expected developments over the next 40 years are then examined, with particular reference to the various alternative combinations of reactor systems and fuel cycles which might be adopted. This leads to the consideration of optimum inter-relations between different possible fuel cycles. The importance is also stressed of considering national nuclear power programmes in Europe in the light of the advantages offered by large and if possible international unit integrated in the fuel cycle. (auth)

**18555** UNUSUAL CORROSION PROBLEMS ASSOCIATED WITH A BOILING WATER REACTOR. Hartman, C. J.; Axtell, C. E. (Big Rock Point Nuclear Plant, Charlevoix, Mich.). pp 405-8 of Proceedings of the 25th Conference of the National Association of Corrosion Engineers. Houston, Tex.; National Association of Corrosion Engineers (1970).

From 25th Annual Conference of the National Association of Corrosion Engineers, Houston, Tex. See CONF-690304.

The Big Rock Point Nuclear Plant primary system design and operation are described. Results of a comprehensive program of feedwater tests started at the time of initial plant operation are reviewed. Corrosion product levels in the feedwater train at various periods are tabulated. The high levels of corrosion products in the system are attributed to the copper alloy tube bundles in the feedwater heaters. These levels decreased sharply when replacement stainless steel tube bundles were installed. (H.D.R.)

**18556** DEVELOPMENT OF NUCLEAR POWER ENGINEERING IN THE SOVIET UNION: OPERATION EXPERIENCES AT THE NUCLEAR POWER PLANT AT NOVOVORONEZH. Grigoryants, A. N.; Ovchinikov, F. Ya.; Voronin, L. M. Energ. Atomtech.; 22: 331-8(Jul 1969). (In Hungarian).

The role of nuclear power plants in the world energy production is discussed. Power production in the Soviet Union is examined, and the role of nuclear plants in power supply is described. The design characteristics of Unit 1 of the Novovoronezh Nuclear Power Plant are outlined and its special construction and operating features are described. Some of the present and planned nuclear power plant development activities are discussed. (auth)

**18557** PROCEEDINGS OF THE 25th CONFERENCE OF THE NATIONAL ASSOCIATION OF CORROSION ENGINEERS, HOUSTON, TEXAS, MARCH 10–14, 1969. Houston, Tex.; National Association of Corrosion Engineers (1970). 716p. $30.00. (CONF-690304).

Included are 97 papers on materials corrosion studies with the primary emphasis placed on corrosion measurement and control techniques. Various aspects of corrosion problems in the water chemistry of nuclear power plants and in reactor system decontamination by chemical cleaning are discussed in 12 papers. A separate abstract was prepared for each of these 12 papers. (H.D.R.)

*For abstracts of individual papers see: 17212–17217, 18555, and 18558–18562.*

**18558** WATER CHEMISTRY AT DRESDEN NUCLEAR POWER STATION. Sisson, A. Bayard (Commonwealth Edison Co., Chicago). pp 385-9 of Proceedings of the 25th Conference of the National Association of Corrosion Engineers. Houston, Tex.; National Association of Corrosion Engineers (1970).

From 25th Annual Conference of the National Association of Corrosion Engineers, Houston, Tex. See CONF-690304.

The chemical program at Dresden is discussed with emphasis on the analyses that are made. Water specifications for the various systems are tabulated, and the procedures for system cleaning prior to startup are briefly described. The routine chemical and radiochemical analyses are tabulated and some typical results are discussed. Demineralizer operation and water treatment in the feedwater, reactor water, and secondary steam generators are examined. (H.D.R.)

**18559** CHEMISTRY AT THE INDIAN POINT NUCLEAR POWER STATION. Stein, W. (Consolidated Edison Co., New York). pp 390-6 of Proceedings of the 25th Conference of the National Association of Corrosion Engineers. Houston, Tex.; National Association of Corrosion Engineers (1970).

From 25th Annual Conference of the National Association of Corrosion Engineers, Houston, Tex. See CONF-690304.

The Indian Point primary water system, boron addition system, spent fuel transfer and cooling system, primary blowdown purification system, and makeup water treatment system are described and the principal system materials are tabulated. Water chemistry aspects of startup and operation are described, and some typical results of water analyses are presented. (H.D.R.)

**18560** CLOSED CYCLE YANKEE, ROWE REACTOR PLANT OPERATING EXPERIENCE. Connally, J. (Yankee Atomic Electric Co., Rowe, Mass.). pp 397-8 of Proceedings of the 25th Conference of the National Association of Corrosion Engineers. Houston, Tex.; National Association of Corrosion Engineers (1970).

From 25th Annual Conference of the National Association of Corrosion Engineers, Houston, Tex. See CONF-690304.

The Yankee primary cooling system is described, and chemical control procedures are discussed. Experiences with tritium formation and primary system equipment maintenance are presented. (H.D.R.)

**18561** CHEMISTRY AND WASTE MANAGEMENT AT THE CONNECTICUT YANKEE ATOMIC POWER PLANT. Graves, R. H. (Northeast Utilities Service Co., Hartford, Conn.). pp 399-404 of Proceedings of the 25th Conference of the National Association of Corrosion Engineers. Houston, Tex.; National Association of Corrosion Engineers (1970).

From 25th Annual Conference of the National Association of Corrosion Engineers, Houston, Tex. See CONF-690304.

The design and operation of the chemically oriented systems of the Connecticut Yankee plant are discussed. Results of chemical and radiochemical analyses are reviewed. The major systems described are the chemical and volume control, sampling, and the boron recovery systems. (H.D.R.)

**18562** WATER CHEMISTRY AT SAN ONOFRE. Sullivan, M. K. (San Onofre Nuclear Generating Station, San Clemente, Calif.). pp 409-12 of Proceedings of the 25th Conference of the National Association of Corrosion Engineers. Houston, Tex.; National Association of Corrosion Engineers (1970).

From 25th Annual Conference of the National Association of Corrosion Engineers, Houston, Tex. See CONF-690304.

The San Onofre primary system and turbine plant design and operation are described, and the materials of construction are tabulated. Analyses and control procedures used in the reactor cooling system and in the radioactive waste disposal system are discussed. (H.D.R.)

**18563** ITALY SCALES UP NUCLEAR CAPABILITY. Angelini, Arnaldo M. (Ente Nazionale per l'Energia Elettrica, Rome). Power; 114: No. 3, 67(Mar 1970).

The operating histories of the Garigliano, Latina, and Trino Vercellese power stations are tabulated. Plans for the construction of a second-generation 800 MW(e) boiling water reactor plant are described. (H.D.R.)

**18564** THE INTERNATIONAL CONFERENCE ON CONSTRUCTIVE USES OF ATOMIC ENERGY, PROCEEDINGS OF THE PLENARY SESSIONS, WASHINGTON, D. C., NOVEMBER 10 – 15, 1968. Farmakes, Ruth (ed.). Hinsdale, Ill.; American Nuclear Society (1969). 398p. $24.00. (CONF-681101).

Topics discussed include: performance and evolution of current generation power reactors; advanced thermal reactors; international safeguards; isotope production and applications; reprocessing of thermal reactor fuels; and fast breeders. Separate abstracts are presented for 30 of the 32 papers included. Two of the papers related to EURATOM nuclear materials management safeguards and to applications of radioisotopes. (D.C.C.)

*For abstracts of individual papers see: 16666–16669, 16802, 16803, 17188, 18565–18576, 18610, 18611, 18666–18669, 18682, 18683, and 18691–18693.*

**18565** REVIEW OF EXPERIENCE WITH LIGHT-WATER-MODERATED POWER REACTORS. Stern, Theodore (Westinghouse Electric Corp., Pittsburgh). pp 13-24 of The International Conference on Constructive Uses of Atomic Energy. /Farmakes, Ruth (ed.). Hinsdale, Ill.; American Nuclear Society (1969).

From International Conference on the Constructive Uses of Atomic Energy, Washington, D. C. See CONF-681101.

Problems encountered in the development of water-moderated power reactors are reviewed. The development evolution of reactor components is described. The long-range potential of the water-moderated power reactor is analyzed. 13 references. (D.C.C.)

**18566** COMMENTARY ON EXPERIENCE WITH LIGHT-WATER REACTORS. Richards, R. B. (General Electric Co., San Jose, Calif.). pp 25-30 of The International Conference on Constructive Uses of Atomic Energy. /Farmakes, Ruth (ed.). Hinsdale, Ill.; American Nuclear Society (1969).

From International Conference on the Constructive Uses of Atomic Energy, Washington, D. C. See CONF-681101.

A brief review of boiling water power reactor development is presented. Design features of the Dresden Power Reactor Units 1 and 2 and the Browns Ferry Power Reactor Unit 1 are compared. Design problems are analyzed. (D.C.C.)

**18567** REVIEW OF EXPERIENCE WITH HEAVY-WATER-MODERATED POWER REACTORS (ESPECIALLY EXPERIENCE RELEVANT TO FUTURE PROSPECTS). Lewis, W. Bennett (Atomic Energy of Canada Ltd., Chalk River, Ont.). pp 31-5 of The International Conference on Constructive Uses of Atomic Energy. /Farmakes, Ruth (ed.). Hinsdale, Ill.; American Nuclear Society (1969).

From International Conference on the Constructive Uses of Atomic Energy, Washington, D. C. See CONF-681101.

Operating experiences discussed include: price of fabricated fuel; fuel burnup; station thermal-to-electrical conversion efficiency; pressure tube replacement; on-power refueling; emergency provisions; heavy water leaks and losses; heavy water coolant pumps; xenon poison; ruptured fuel monitoring; and water chemistry control. 17 references. (D.C.C.)

**18568** COMMENTARY ON REVIEW OF EXPERIENCE WITH HEAVY-WATER-MODERATED POWER REACTORS. Holmes, J. E. R. (Atomic Energy Establishment, Winfrith, Eng.). pp 36-7 of The International Conference on Constructive Uses of Atomic Energy. /Farmakes, Ruth (ed.). Hinsdale, Ill.; American Nuclear Society (1969).

From International Conference on the Constructive Uses of Atomic Energy, Washington, D. C. See CONF-681101.

**18569** A REVIEW OF EXPERIENCE WITH GAS-COOLED REACTORS. Moore, R. V. (United Kingdom Atomic Energy Authority, Risley, Eng.). pp 38-53 of The International Conference on Constructive Uses of Atomic Energy. /Farmakes, Ruth (ed.). Hinsdale, Ill.; American Nuclear Society (1969).

From International Conference on the Constructive Uses of Atomic Energy, Washington, D. C. See CONF-681101.

Operation experiences for world-wide gas-cooled power reactors are analyzed. The performances of reactor components are compared. (D.C.C.)

**18570** COMMENTARY ON EXPERIENCE WITH GAS-COOLED POWER REACTORS. Tanguy, P. (Commissariat a l'Energie Atomique, Saclay, France). pp 54-6 of The International Conference on Constructive Uses of Atomic Energy. /Farmakes, Ruth (ed.). Hinsdale, Ill.; American Nuclear Society (1969).

From International Conference on the Constructive Uses of Atomic Energy, Washington, D. C. See CONF-681101.

Problems related to operating gas-cooled power reactors in France are described. Components which required revisions in design are discussed. (D.C.C.)

**18571** HEAVY-WATER-MODERATED REACTORS: STATUS AND PROSPECTS. Margen, P. H. (Aktiebolaget Atomenergie, Stockholm). pp 87-110 of The International Conference on Constructive Uses of Atomic Energy. /Farmakes, Ruth (ed.). Hinsdale, Ill.; American Nuclear Society (1969).

From International Conference on the Constructive Uses of Atomic Energy, Washington, D. C. See CONF-681101.

Present development programs for heavy water-moderated power reactors are reviewed. Design parameters for existing heavy water-moderated power reactors are compared. Economics for reactor operation are analyzed. 23 references. (D.C.C.)

**18572** THE IAEA SAFEGUARDS SYSTEM. Eklund, S. (International Atomic Energy Agency, Vienna). pp 133-5 of The International Conference on Constructive Uses of Atomic Energy. /Farmakes, Ruth (ed.). Hinsdale, Ill.; American Nuclear Society (1969).

From International Conference on the Constructive Uses of Atomic Energy, Washington, D. C. See CONF-681101.

**18573** SAFEGUARDS AND NUCLEAR MATERIALS MANAGEMENT IN THE USA. Crowson, Delmar L. (Atomic Energy Commission, Washington, D. C.). pp 140-7 of The International Conference on Constructive Uses of Atomic Energy. /Farmakes, Ruth (ed.). Hinsdale, Ill.; American Nuclear Society (1969).

From International Conference on the Constructive Uses of Atomic Energy, Washington, D. C. See CONF-681101.

**18574** TECHNICAL REQUIREMENTS FOR INTERNATIONAL SAFEGUARDS. Arsenault, F.; Shmelev, V. (International Atomic Energy Agency, Vienna). pp 148-51 of The International Conference on Constructive Uses of Atomic Energy. /Farmakes, Ruth (ed.). Hinsdale, Ill.; American Nuclear Society (1969).

From International Conference on the Constructive Uses of Atomic Energy, Washington, D. C. See CONF-681101.

**18575** SAFEGUARDS, INTERNATIONAL COOPERATION, AND TRADE. Kratzer, Myron B. (Atomic Energy Commission, Washington, D. C.). pp 180-3 of The International Conference on Constructive Uses of Atomic Energy. /Farmakes, Ruth (ed.). Hinsdale, Ill.; American Nuclear Society (1969).

From International Conference on the Constructive Uses of Atomic Energy, Washington, D. C. See CONF-681101.

**18576** THE NEGOTIATION OF SAFEGUARDS IN THE NON-PROLIFERATION TREATY. Scoville, Herbert Jr. (Arms Control and Disarmament Agency, Washington, D. C.). pp 184-7 of The International Conference on Constructive Uses of Atomic Energy. /Farmakes, Ruth (ed.). Hinsdale, Ill.; American Nuclear Society (1969).

From International Conference on the Constructive Uses of Atomic Energy, Washington, D. C. See CONF-681101.

**18577** ENGINEERING ASPECTS OF THERMAL POLLUTION. Proceedings of the National Symposium, Nashville, Tennessee, August 14–16, 1968. Parker, Frank L.; Krenkel, Peter A. (eds.). Nashville; Vanderbilt University Press (1969). 371p. $7.95. (CONF-680845).

The effects of fossil fuel and nuclear power plant thermal effluents on the environment are analyzed. Topics discussed include: definition of present and predicted waste heat problems; ecological changes induced by discharge of heated waters; water-quality standards for temperature; cooling of riverside thermal power plants; mechanics of condenser-water discharge from thermal power plants; modeling of heated-water discharges; the horizontal traveling screen; design and operation of cooling towers; economic considerations in thermal discharge to streams; and research needs for thermal effluent control. (D.C.C.)

## Power Reactor Development

*Refer also to abstracts 16807, 16818, 17192, 17197, 17227–17229, 17256, 17343, and 18564.*

**18578** (AEC-tr-7130) PHENIX, PROTOTYPE FAST-NEUTRON NUCLEAR POWER STATION. Translation of selected articles from Bull. Inform. Sci. Tech. (Paris), No. 138 (Jun 1969). 226p. Dep. CFSTI.

Problems related to the development and construction of the prototype fast power reactor Phenix are described. Design parameters for the reactor systems are presented. (D.C.C.)

**18579** (AI-AEC-12792(Vol.2)) 1000-MWe LIQUID METAL FAST BREEDER REACTOR FOLLOW-ON STUDY CONCEPTUAL DESIGN REPORT. VOLUME II. ENGINEERING STUDIES. Task III Report. Aronstein, R. E.; Casey, D. F. (eds.) (Atomics International Canoga Park, Calif.). [nd]. Contract ANL-31-109-38-1996. 307p. Dep. CFSTI.

For Argonne National Lab., Ill.

The conceptual design engineering studies performed by Atomics International for the Liquid Metal Fast Breeder Reactor (LMFBR) program are detailed. The analytical models are described for fuel heat-transfer, core thermal-hydraulics, reactor physics, fuel cycle cost, fuel burnup, plant heat balance, capital cost, and plant availability. Core and systems parameter studies are outlined. Effects of uncertainties in basic design data are considered. Regular and modular core geometries are compared; steam generator and plant arrangement studies are discussed. The economics of the LMFBR concept are evaluated. (M.L.S.)

**18580** (AI-AEC-12792(Vol.4)) 1000-Mwe LIQUID METAL FAST BREEDER REACTOR FOLLOW-ON STUDY CONCEPTUAL DESIGN REPORT. VOLUME IV. DESCRIPTION OF PLANT DESIGN. (Atomics International, Canoga Park, Calif.). [1968]. Contract ANL-31-109-38-1996. 321p. Dep. CFSTI.

For Argonne National Lab., Ill.

A complete description of the Atomics International LMFBR plant design is given. Design bases and plant configuration are established. Plant structures, core, fuel handling system, sodium heat transfer system, turbine generator plant, instrumentation and control systems, electrical systems, and auxiliary systems are described. (M.L.S.)

**18581** (ANL-7655) REACTOR DEVELOPMENT PROGRAM PROGRESS REPORT, DECEMBER 1969. (Argonne National Lab., Ill.). 29 Jan 1970. Contract W-31-109-eng-38. 139p. Dep. CFSTI.

Highlights of project activities for December 1969 are summarized. LMFBR physics development, component development, and sodium technology are reviewed. Operations and analysis of the ZPR-3, ZPR-6, ZPR-9, and ZPPR are described. The EBR-II research and development projects, fuel fabrication, and operations are summarized. Reactor fuels and materials development, physics studies, reactor engineering, reactor chemistry, LMFBR safety, and thermal effluent studies are reported. (H.D.R.)

**18582** (ANL-7661) REACTOR DEVELOPMENT PROGRAM PROGRESS REPORT, JANUARY 1970. (Argonne National Lab., Ill.). 25 Feb 1970. Contract W-31-109-eng-38. 137p. Dep. CFSTI.

Highlights of project activities for January 1970 are summarized. LMFBR physics development, component development, sodium technology, and 1000 MW(e) plant development are reviewed. Operations and analysis of the ZPR-3, ZPR-9, and ZPPR are described. The EBR-II research and development projects, fuel fabrication, and operations are summarized. Reactor fuels and materials development, physics studies, engineering development, fuel cycle chemistry, and LMFBR safety studies are reported. (H.D.R.)

**18583** (DOCKET-50231-41) SOUTHWEST EXPERIMENTAL FAST OXIDE REACTOR. [Preliminary Safety Analysis Report], Amendment 5. (General Electric Co., Sunnyvale, Calif. Advanced Products Operation). 25 Jul 1967. 12p. Dep. CFSTI.

General information relating to the Southwest Atomic Energy Associates and General Electric Company, owners of the Southwest Experimental Fast Oxide Reactor (SEFOR) is given. Qualifications of responsible GE personnel are summarized. (M.L.S.)

**18584** (DOCKET-50231-42) SOUTHWEST EXPERIMENTAL FAST OXIDE REACTOR. [Preliminary Safety Analysis Report], Amendment 22. (General Electric Co., Sunnyvale, Calif. Advanced Products Operation). 1 Oct 1968. 2p. Dep. CFSTI.

SOUTHWEST EXPERIMENTAL FAST OXIDE REACTOR — operation of, estimated costs for 1968–1971 (M.L.S.)

**18585** (GA-9815) HTGR BASE PROGRAM. Quarterly Progress Report for the Period Ending November 30, 1969. (Gulf General Atomic, Inc., San Diego, Calif.). 30 Dec 1969. Contract AT(04-3)-167. 42p. Dep. CFSTI.

GRAPHITE — diffusion of strontium in
— radiation effects on creep and dimensional stability of, neutron
NEUTRONS — effects on graphite creep and dimensional stability
REACTOR FUEL ELEMENTS — reprocessing cycle for HTGR type
REACTOR FUELS — radiation testing of coated particle
— fission product release from coated particle
REACTORS, GAS COOLED — development of 1000 MW(e) HTGR concept during Sept. through Nov. 1969
— fuel recycle for HTGR type
— fuels for, development of coated particle
REACTORS, POWER — development of 1000 MW(e) HTGR concept during Sept. through Nov. 1969
STRONTIUM — diffusion in graphite
— vapor pressure over graphite in presence of carbon monoxide
STRONTIUM ISOTOPES Sr-90 — retention by irradiated coated particle fuels, in-pile
THORIUM CARBIDES — fission product release from coated particle fuels of
THORIUM OXIDES $ThO_2$ — $ThO_2$–$UO_2$, stability of BISO coated particles of, during fluidized bed oxidation
URANIUM CARBIDES — fission product release from coated particle fuels of
URANIUM OXIDES $UO_2$ — $ThO_2$–$UO_2$, stability of BISO coated particles of, during fluidized bed oxidation
— fission product release from coated particle fuels of (H.D.R.)

**18586** (KFK-964) DEVELOPMENT OF FAST BREEDERS. 1969 Reactor Conference of the German Atomic Forum, 15–18 April 1969, Frankfurt am Main, Germany. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Reaktorentwicklung). Apr 1969. 142p. (In German). (EUR-4171; CONF-690419).

Topics related to development programs for fast breeder reactors are discussed. Separate abstracts are included for each of the 11 papers presented. (D.C.C.)

*For abstracts of individual papers see: 18615, 18616, 18632, 18633, 18649–18653, 18673, and 18687.*

**18587** (ORNL-4449) MOLTEN-SALT REACTOR PROGRAM. Semiannual Progress Report for Period Ending August 31, 1969. (Oak Ridge National Lab., Tenn.). Feb 1970. Contract W-7405-eng-26. 252p. Dep. CFSTI.

Research and development progress is reported in five sections. A separate abstract was prepared for each section. (J.R.D.)

*For abstracts of individual sections see: 16486, 16625, 17331, 18588, and 18677.*

**18588** (ORNL-4449, pp 39-95) MSBR DESIGN AND DEVELOPMENT. Briggs, R. B. (Oak Ridge National Lab., Tenn.).

BERYLLIUM FLUORIDES — $BeF_2$–LiF–$ThF_4$–$UF_4$, heat transfer coefficients of molten, flowing in small diameter tubes
FUSED SALTS — thermal conductivities of MSRE and MSBR coolants and fuels
LITHIUM FLUORIDES — $BeF_2$–LiF–$ThF_4$–$UF_4$, heat transfer coefficients of molten, flowing in small diameter tubes
LOOPS — operation of sodium fluoroborate circulating test, corrosion product deposition and off gas emission during
MACHINING — equipment development for remote, for nuclear power plant maintenance
MOLTEN SALT BREEDER EXPERIMENT — fuel for, design of ALPHA pump for
— core design parameters for conceptual, with spherical reactor vessels
MOLTEN SALT BREEDER REACTOR — core for, spatial distributions of $\gamma$ and neutron heating in
— reactivity perturbations in, system response to
— fuel system for, corrosion product deposition in
— maintenance of, remote cutting and welding development for
— fuel system for, heat transfer coefficients for
— fuel for, thermal conductivity of
— design parameters for 1000 MW(e), summary of
— building arrangement for 1000 MW(e)
— waste storage pit for, cooling requirements for
— fuel for, design and operation of primary drain tank for
— heat exchangers for, $\gamma$ heating in
— physics analysis of
— performance of, effect of power rating on
— performance of blanketed canned-core, effect of design variations on
MOLTEN SALT REACTOR EXPERIMENT — fuel for, uranium-235 capture to absorption ratio in
PUMPS (LIQUID METAL) — design for MSBE fuel salt
THORIUM FLUORIDES $ThF_4$ — $BeF_2$–LiF–$ThF_4$–$UF_4$, heat transfer coefficients of molten, flowing in small diameter tubes
URANIUM FLUORIDES $UF_4$ — $BeF_2$–LiF–$ThF_4$–$UF_4$, heat transfer coefficients of molten, flowing in small diameter tubes

WELDING—equipment development for remote, for nuclear power plant maintenance (H.D.R.)

**18589** (TID–25349) APPLICATION OF ADVANCED DYNAMIC PROGRAMMING COMPUTATIONAL PROCEDURES TO THE PLANNING OF NUCLEAR FUEL REPROCESSING PLANTS AND NUCLEAR POWER REACTORS. Final Report. Larson, R. E.; Rees, F. J. (Wolf Management Services, Palo Alto, Calif.). Nov 1969. Subcontract 3240. 68p. Dep. CFSTI.

For Oak Ridge National Lab., Tenn.

Presented are the results of a project to assess the feasibility of applying advanced dynamic programming computational procedures to two planning problems of concern to the Atomic Energy Commission, namely the planning of nuclear power reactor types and the planning of nuclear fuel reprocessing plants. In both cases the feasibility was assessed by solving low-dimensional problems that have all the characteristics of the realistic problem. As a result of this study, algorithms that show considerable promise in the realistic, high-dimensional reactor planning problem have been developed. In the case of reprocessing plant problems, algorithms are now available that can be extended to the realistic high-dimensional problem. (14 references) (auth)

**18590** TOP-PRIORITY PROGRAM: THE FAST BREEDER REACTOR. Shaw, Milton (Atomic Energy Commission, Washington, D. C. Nucl. News; 13: No. 3, 49-53(Mar 1970).

The U. S. program for development of a Na-cooled fast breeder reactor is reviewed. Na-cooled reactor facilities and research programs are described, and plans for demonstration plant construction are discussed. (H.D.R.)

**18591** SEFOR CONSTRUCTION, OPERATION: PRELUDE TO LMFBR DEVELOPMENT. Fidrych, L. F.; Arterburn, J. O. Nucl. News; 13: No. 3, 53-7(Mar 1970).

The Southwest Experimental Fast Oxide Reactor research and development program objectives are described. Design and construction aspects are examined, and operational testing of the reactor is reviewed. (H.D.R.)

**18592** STATE AND DEVELOPMENT OF THE SOVIET POWER REACTORS COOLED AND MODERATED BY WATER. Raszl, Karoly; Toekoeli, Miklos. Energ. Atomtech.; 21: 491-512(Sep 1968). (In Hungarian).

The research and developing tasks for power reactors surpassing 400 MW capacity cooled and moderated by water are described. Reactor physics, technology at the primary cycle, control techniques for power plants, and fuel element cycle are analyzed. 55 references. (auth)

**18593** HIGH PERFORMANCE BREEDER AS A PRIMARY DEVELOPMENT GOAL. Storrs, C. L.; Staker, W. P.; Noyes, R. C. (Combustion Engineering Inc., Windsor, Conn.). Proc. Amer. Power Conf.; 31: 104-15(1969).

From American Power Conference, Chicago, Ill. See CONF-690439.

Safety characteristics of a high performance breeder reactor are described. Optimum modular and cylindrical cores are compared; design parameters are tabulated for each. Core thermal design criteria are tabulated for oxide and carbide fuel. Parametric studies of a sodium-bonded reference core are detailed; performance characteristics are tabulated. The relationship between specific power and reference reactor characteristics is evaluated; effects of fuel burnup on overall reactor performance are analyzed. (M.L.S.)

**18594** GAS-COOLED FAST BREEDER REACTOR DEVELOPMENT: DESIGN OF A 330-MW DEMONSTRATION POWER PLANT. Fortescue, Peter (Gulf General Atomic Inc., San Diego, Calif.). Proc. Amer. Power Conf.; 31: 116-24 (1969).

From American Power Conference, Chicago, Ill. See CONF-690439.

Primary and secondary containment and expected operating conditions for the gas-cooled fast breeder (GCFR) reactor are discussed. Plant size and fuel enrichment requirements for a 33D MWe plant are tabulated. Basic plant design is described; some design parameters are listed. (6 references) (M.L.S.)

**18595** DESIGN AND OPERATIONAL CHARACTERISTICS OF A 1000-MWE COMMERCIAL LIQUID METAL FAST BREEDER REACTOR PLANT. Aronstein, R. E.; Ash, E. B.; Casey, D. F. (Atomics International, Canoga Park, Calif.). Proc. Amer. Power Conf.; 31: 125-43(1969).

From American Power Conference, Chicago, Ill. See CONF-690439.

The utility support program for the development of the Atomics International LMFBR concept into a commercially feasible nuclear power plant is discussed. The overall plant is described; development scheduling is outlined. Performance and operational characteristics are described; design parameters are tabulated for a 500 MW(e) demonstration plant and for a commercial 1000 MW(e) plant. Relative thermal effluent factors are compared for an LWR and LMFBR. Operation and load response are discussed; safety features are outlined. Systems and component maintainability is described. (9 references) (M.L.S.)

**18596** FUEL MANAGEMENT FOR LMFBR PLANTS. Beeley, R. J.; Buttrey, K.; Golan, S. (Atomics International, Canoga Park, Calif.). Proc. Amer. Power Conf.; 31: 180-99(1969).

From American Power Conference, Chicago, Ill. See CONF-690439.

The physics and reactivity control associated with fuel management for LMFBR plants is discussed. Breeding ratios are compared for the LWR and LMFBR. Effects of thermal and hydraulic characteristics on the overall cost/kwh are evaluated. Fuel cycle costs and the plutonium and uranium markets are considered. Spent fuel characteristics are tabulated for the LWR and LMFBR. Incremental operating costs are given; typical design and operating parameters are tabulated. (9 references) (M.L.S.)

**18597** UTILITY APPLICATION OF THE MOLTEN SALT BREEDER REACTOR. Jensen, Roland J. (Northern States Power Co., Minneapolis); Swanson, Einar. Proc. Amer. Power Conf.; 31: 222-30(1969).

From American Power Conference, Chicago, Ill. See CONF-690439.

A basic history and description of the molten salt reactor are given. A simplified flow diagram of the molten salt reactor cycle is shown. Advantages and disadvantages are compared. Scheduling for a molten salt power reactor prototype is considered. (7 references) (M.L.S.)

**18598** TEKHNICHESKIE PROBLEMY REAKTOROV NA BYSTRYKH NEITRONAKH. (Fast Neutron Reactor Technology). Bagdasarov, Yu. E.; Pinkhasik, M. S.; Kuznetsov, I. A.; Kozlov, F. A.; Baklushin, R. P.; Rineiskii, A. A.; Poplavskii, V. M.; Milovidov, I. V.; Petrenko, A. A.; Arkhangel'skii, V. V. Moscow; Atomizdat (1969). 612p.

The technological design problems of liquid Na-cooled fast reactors in U.S.S.R. are analyzed. A discussion of peculiarities of construction of Na equipment is presented. (405 references) (tr-auth)

**18599** REACTOR TECHNOLOGY. VOLUME 13, NUMBER 1. One of Four Technical Progress Reviews Published for the Division of Technical Information, USAEC. Washington, D. C.: Atomic Energy Commission (Winter 1969–1970). 100p. GPO $0.75.

Included are 8 articles on various aspects of nuclear reactor development and technology. A separate abstract was prepared for each article. (H.D.R.)

*For abstracts of individual papers see: 18540, 18600–18603, 18644, 18660, and 18776.*

**18600** FAST BREEDER REACTOR PROGRAM IN EUROPE. Forcella, Aldo (Nuclear Associates International Corp., Rockville, Md.). Reactor Technol.; 13: 1-6(Winter 1969–70).

Fast breeder reactor development in Western Europe is concentrated in separate programs in the United Kingdom, France, Italy, and Benelux—Federal Republic of Germany. All four programs employ sodium cooling systems and mixed oxide fuel. The status of the PFR, Phenix, and SNR prototype plants is described, and development of sodium components, fuel, reactor physics, and fuel reprocessing are reviewed. 31 references. (H.D.R.)

**18601** GAS-TURBINE NUCLEAR POWER PLANTS. Katterhenry, A. A. (Southern Nuclear Engineering, Inc., Dunedin, Fla.). Reactor Technol.; 13: 7-13(Winter 1969–70).

The advantages and disadvantages of the direct gas-turbine power cycle are compared with a conventional steam cycle. Gas cooled reactor development in Europe and the U. S. is examined. The 25 MW(e) KSH plant development is described in detail. Future development areas of direct cycle gas turbine plants are discussed, including fast breeders. 17 references. (H.D.R.)

**18602** DEVELOPMENT OF FAST BREEDERS. Haefele, W. (Kernforschungszentrum, Karlsruhe, Ger.). Reactor Technol.; 13: 18-35(Winter 1969–70). (CONF-681101–30).

From International Conference on the Constructive Uses of Atomic Energy, Washington, D. C.

The history of fast breeder reactor development in Europe and the U. S. is reviewed. Fast breeder development programs are described, and characteristics of the principal research facilities are tabulated. Some of the properties and performance of fast reactor fuels, materials, and components are examined. 87 references. (H.D.R.)

**18603** SYSTEM AND COMPONENT DESIGN FOR FAST REACTORS. Koch, L. J. (Argonne National Lab., Ill.). Reactor Technol.; 13: 36-53(Winter 1969-70). (CONF-681101-41).

From International Conference on the Constructive Uses of Atomic Energy, Washington D. C.

The basic characteristics of sodium-cooled and helium-cooled fast breeder reactor systems are compared. Design aspects of the cooling system, steam supply system, fuel handling system, safety systems, and system components are examined with respect to performance, reliability, maintainability, and replaceability. 5 references. (H.D.R.)

**18604** FAST BREEDER REACTORS. Ritz, Heinrich Ludolf (Gesellschaft fuer Kernforschung mbH, Karlsruhe, Ger.). Elektrotech. Z.; A90: 522-5(26 Sep 1969). (In German).

Fast breeder reactors are reviewed from the point of view of the breeder concept, the Na-cooled breeder reactor, some alternatives to the Na-cooled breeder, the $D_2O$ steam-cooled breeder, and the gas-cooled breeder reactor. The fast breeder reactors represent a necessary extension of the thermal reactors which are being increasingly used in nuclear power stations. While the evolution of thermal reactors began with a number of possible systems, which with increasing experience was reduced to a few, in the case of breeder reactors only 3 systems are being considered, one of which is of worldwide interest. The reason for its prime position are given and the problems are outlined which still have to be solved. The two alternatives are considered and compared, and their possibilities and uncertainties listed. In the case of the steam-cooled breeder, the use of $D_2O$ and $H_2O$ in the primary circuit is compared. Use of He in the gas-cooled breeder is discussed as well as the possible development of a He turbine. Gas-cooled fast breeders with an electrical capacity of 1000 MW are envisioned. (BBB)

**18605** PRESENT STATE AND DEVELOPMENTS OF HIGH-TEMPERATURE GAS-COOLED (HTGC) REACTORS. Oehme, Helmut; Stuermer, Walter (Brown, Boveri/Krupp Reaktorbau GmbH, Mannheim, Ger.). Elektrotech. Z.; A90: 517-22(26 Sep 1969). (In German).

After a review of the important features and the lines of development of gas-cooled reactors, material problems and problems of core design, questions of gas purity, the ability to retain fission products in the fuel elements, and prestressed concrete pressure vessels are discussed. In addition to an account of operational experience, the typical features of the various reactors are presented in table form. In regard to development trends, reference is made to gas turbine units with high-temperature reactors, producing heat for chemical processes, and gas-cooled fast breeders. Specifications are stated for the reactors of the Dragon Project (U.K.), Mark III (U.K.), Geesthacht KSH (West Germany), AVR-Atomkraftwerk at Juelich (West Germany), Unit I at Peach Bottom (U.S.), and the Fort St. Vrain Station (U.S.). Diagrams and illustrations of some of these reactors are provided. (BBB)

**18606** STATE AND TRENDS IN THE DEVELOPMENT IN THE CONSTRUCTION OF REACTORS IN THE GERMAN FEDERAL REPUBLIC. Ording, Buchard (Deutsches Atomforum e. V., Bonn). Elektrotech. Z.; A90: 483-7(26 Sep 1969). (In German).

The present state of nuclear reactor development in West Germany is reviewed, including historical aspects, introduction of the light-water reactor into Germany, design and construction of second-generation reactors, and the fuel cycle. Plans for future development, especially as regards light- and heavy-water reactors, the high-temperature reactor, and the Na-cooled fast breeder, are discussed. At present only about 1% of the total current requirement in the German Federal Republic is met by nuclear energy, but in 1980 it will amount to 20 to 25%. On the basis of the constructional and operating experience gained from experimental nuclear power stations in the German Federal Republic, nuclear power stations having capacities between 600 and 1200 MW have been ordered. Mainly light-water-cooled reactors have been provided for. Improvements are continuously being made on light- and heavy-water-cooled reactors (the latter are especially of interest for export), but mainly high-temperature reactors and fast breeder reactors are being developed. The review mentions the state of development of individual reactor types. Development of reactors for marine and aviation applications are also considered. (BBB)

**18607** CONSTRUCTION OF NUCLEAR COMPONENTS: STANDARDIZATION. Com. Naz. Energ. Nucl., Notiz.; 16: 72-6(Jan 1970). (In Italian).

Problems and requirements in the fabrication of nuclear power plant components are reviewed. Problems with standardization and fabrication are outlined for: heat exchangers, pressure vessels, containment systems, fuel elements, fuel loading-unloading machine, control rods, coolant pumps, turbine-generators, safety and control systems and instrumentation, and core and intervals. (M.L.S.)

**18608** NUCLEAR POWER IN JAPAN. Casa, A. F.; Pascucci, M. L.; Perilli, M. L.; Sansone, M. Com. Naz. Energ. Nucl., Notiz.; 16: 33-44(Jan 1970). (In Italian).

Japan's main nuclear activities are discussed in 4 sections, concerning respectively the Nation's nuclear power program from its inception to the present, the uranium supply situation, the nuclear fuel activities and the work done in the field of radiation chemistry and radioisotopes. (auth)

**18609** PARAMETERS OF PRESSURIZED WATER NUCLEAR POWER STATIONS. Gyimesi, Zoltan; Ocsai, Mihaly. Energ. Atomtech.; 22: 39-44(Jan 1969). (In Hungarian).

The development stages of pressurized water reactors are outlined, and various installations are analyzed and compared. The reactors discussed are mainly in nuclear power stations. Some of the basic characteristics of the steam supply cycle are examined. (auth)

**18610** DEVELOPMENT OF FAST BREEDERS. Haefele, W. (Kernforschungszentrum, Karlsruhe, Ger.). pp 325-42 of The International Conference on Constructive Uses of Atomic Energy. /Farmakes, Ruth (ed.). Hinsdale, Ill.; American Nuclear Society (1969).

From International Conference on the Constructive Uses of Atomic Energy, Washington, D. C. See CONF-681101.

A review of the development of first generation fast breeder reactors is presented. A list of design parameters is included for the first generation reactors. Critical assemblies used in fast breeder reactor research are described. Requirements for fast breeder reactor physics and fuel elements are analyzed. Safety parameters in fast breeder reactor designs are outlined. Coolant performances are compared. A survey of present worldwide fast breeder reactor development programs is presented. 87 references. (D.C.C.)

**18611** SYSTEM AND COMPONENT DESIGN FOR FAST REACTORS. Koch, L. J. (Argonne National Lab., Ill.). pp 343-60 of The International Conference on Constructive Uses of Atomic Energy. /Farmakes, Ruth (ed.). Hinsdale, Ill.; American Nuclear Society (1969).

From International Conference on the Constructive Uses of Atomic Energy, Washington, D. C. See CONF-681101.

Comparisons are presented of design parameters for liquid Na-cooled and He-cooled fast breeder reactors. Components and systems compared include shutdown cooling systems and fuel handling systems. Maintenance requirements for the two types of reactors are described. 5 references. (D.C.C.)

## *Kinetics and Dynamics*

**18612** (AI-AEC-12792(Vol.5)) 1000-Mwe LIQUID METAL FAST BREEDER REACTOR FOLLOW-ON STUDY. TASK III REPORT. CONCEPTUAL DESIGN REPORT METHODS. VOLUME V. METHODS. (Atomics International, Canoga Park, Calif.). [1968]. Contract AN L 31-109-38-1996. 121p. Dep. CFSTI.

For Argonne National Lab., Ill.

The methods of analyses and computer codes used in the Atomics International conceptual design study for a 1000 MW(e) LMFBR are described; results of analyses and calculations are presented in tabular form. Analyses of static reactor characteristics, reactivity coefficients, and burnup and fuel move are described; the microscopic cross section libraries-compiled from the AILMOE, GRISM, and CLIO programs-are listed. Equations used for axial temperature distribution, cladding hot channel factor, and fission gas plenum length determinations are given. System parametric study equations are tabulated. Brief descriptions of all computer codes that were used are included. (M.L.S.)

**18613** (ANL-7652) SUMMARY REVIEW OF NEUTRONIC NOISE TECHNIQUES FOR INCIPIENT BOILING DETECTION IN LIQUID METAL FAST BREEDER REACTORS. Marciniak, T. J.;

Habegger, L. J.; Greenspan, H. (Argonne National Lab., Ill.). Jan 1970. Contract W-31-109-eng-38. 20p. Dep. CFSTI.

The state-of-the-art of neutronic noise-boiling detection is reviewed as part of an overall effort to determine the feasibility of developing a system for detecting the onset of boiling in proposed Na-cooled LMFBR cores. It is concluded that feasibility of a Na-boiling detector is within the realm of existing technology but that many problems related to boiling-induced neutron fluctuations, data-gathering, and computer processing of such data, must be resolved before an effective system can be developed. (82 references) (auth)

**18614** (BAW-3647-15) PHYSICS VERIFICATION PROGRAM. PART III. QUARTERLY TECHNICAL REPORT, JULY-SEPTEMBER 1969. Pettus, W. G.; Baldwin, M. N.; Fairburn, G. T.; Stern, M. E.; Mason, R. C. (Babcock and Wilcox Co., Lynchburg, Va. Research and Development Div.). Dec 1969. Contract AT(30-1)-3647. 50p. Dep. CFSTI.

Experiments to measure the steady state power distribution through critical assembly mockups of typical PWR designs are described. The critical assembly used in the experiments consisted of aluminum clad $UO_2$ fuel rods. Small lattice experiments and zoned or mixed lattice experiments with $UO_2$ and $PuO_2-UO_2$ fuel are described. The measurements of $k_\infty$ for poisoned uniform lattices of various metal-to-water ratios are presented. (4 references) (D.C.C.)

**18615** (KFK-964, Sect. 1.1-12) INVESTIGATION OF SPACE-DEPENDENT DYNAMIC BEHAVIOR OF FAST BREEDER REACTORS WITH A VARIATIONAL PRINCIPLE USING TIME-DISCONTINUOUS APPROXIMATION FUNCTION. Kessler, G.; Struwe, D. (In German).

Externally caused fast breeder excursions and their thermodynamic effects lead to disturbances of the neutron flux which cannot be solved with point kinetics. Therefore, an improved approximation method for computing space- and time-dependent neutron flux is presented. A method for computing temperature distribution and thermodynamic effects is outlined. Validity of the methods is shown by calculating excursions of a Na-cooled fast breeder reactor with 300 MW(e) caused by withdrawal of a control rod. The method is superior to the point theory in evaluating neutron flux and thermodynamic effects of fast breeder excursions. Seven diagrams depict principles and results. (6 references) (H.B.G.)

**18616** (KFK-964, Sect. 6.1-13) STATISTICAL METHOD FOR CALCULATING HOT CHANNEL FACTORS. Amendola, A. (In German).

A new mathematical method is developed which allows computation of core arrangements that are safe from overheating. The theoretical considerations are then applied to an analysis of Na-cooled reactors. Principles of the method and results are presented in three tables and two diagrams. (7 references) (H.B.G.)

**18617** (ORNL-TM-2823) FREQUENCY-RESPONSE TESTING OF THE MOLTEN-SALT REACTOR EXPERIMENT. Steffy, R. C. Jr. (Oak Ridge National Lab., Tenn.). Mar 1970. Contract W-7405-eng-26. 118p. Dep. CFSTI.

Thesis. Submitted to Univ. of Tennessee [Knoxville].

Tests to determine the neutron flux-to-reactivity frequency response were performed on the Molten Salt Reactor Experiment with the reactor at various power levels between zero and full power and with the reactor fueled with a $^{235}U$ fuel mixture. Test patterns employed were pseudorandom binary sequences (PRBS) and pseudorandom ternary sequences (PRTS) of various sequence lengths and minimum-pulse-duration times. In some tests reactivity (control-rod position) was forced to follow the test pattern, and in other tests the neutron flux was forced to follow the test pattern. The experimental results were analyzed by several different methods and the results were compared. The frequency response of the uncontrolled reactor system was found to be in good agreement with theoretical predictions for both the $^{235}U$ and $^{233}U$ fuel loadings. There were no indications of response characteristics that might cause control or safety problems. The power spectra for the various sequences were flat over the expected ranges and variations in the sequence specification changed the power spectra in the expected manner with no anomalous changes. A diagram is presented which makes specification of the spectral characteristics for a particular sequence immediate. For the $^{235}U$ fuel loading, results of the flux-controlled testing using PRBS's and PRTS's were adequate, but for the $^{233}U$ fuel loading, additional system noise coupled with equipment limitations caused excessive scatter in the frequency-response results for both type sequences. For the $^{233}U$ fueled system, a closed-loop method of positioning the control rod and use of a PRBS was necessary to obtain acceptable results. Use of a PRTS with this method of control-rod positioning caused introduction of errors in the indicated control-rod position rendering the test results unacceptable. Experimental data were purposely analyzed at non-harmonic frequencies showing that careful specification of the analysis frequency is necessary for meaningful results. In data containing a large amount of noise, the results of analysis of the same data by the different techniques were found to contain anomalous differences, particularly at the first few harmonic frequencies. Analysis of the data by the different methods for low-noise tests gave results which were in excellent agreement. (auth)

**18618** MINIMUM CRITICAL MASS IN FAST REACTORS WITH BOUNDED POWER DENSITY. Goldschmidt, P.; Quenon, J. (Belgo Nucleaire, Brussels). Nucl. Sci. Eng.; 39: 311-19 (Mar 1970).

A method of optimizing the fissile fuel distribution to obtain minimum critical mass for a fast breeder reactor of fixed power is presented. Constraints on the power density and on the fuel enrichment are considered. The reactor is described by one-group diffusion theory. The optimal trajectory in the phase space (flux-current) is found a priori using the Maximum Principle of Pontryagin. It is shown that in general, the optimum reactor has three distinct regions: a central constant-power-density region, a region of maximum fuel enrichment and an outer region of minimum enrichment corresponding to the blanket. The existence of this last region and its dimension depend on the outer boundary condition which can simulate the presence of an external reflector. The expressions obtained for the optimized dimensions of each region can be solved analytically and numerical results are given. 6 references. (auth)

**18619** MEASUREMENT OF $\delta^{28}$ BY TRACK COUNTING OF FISSION FRAGMENTS IN POLYCARBONATES. Balducci, G. (CNEN, Rome); Bozzi, L.; Mangialajo, M.; Rossini, F. Energ. Nucl. (Milan); 16: 781-6(Dec 1969).

In the framework of the CIRENE program experiments at the RB-1 Reactor, the parameter $\delta^{28}$ has been measured for the three hexagonal pitches (27.4 – 30.2 – 32.2 cm) of the considered configuration, by a new method involving fission fragment track counting in polycarbonate samples (Makrofol-KG) placed in contact with thin and calibrated layers of natural and depleted uranium. Details of the measurement and data processing are described. A comparison is made with the theoretical data from PROCELLA code. (auth)

**18620** HETEROGENEOUS REACTORS FLATTENING BY FUEL RODS ARRANGEMENT. Ponomarev-Stepnoi, N. N.; Glushkov, E. S.; Nosov, V. I.; Barkov, S. N. At. Energ. (USSR); 28: 58-60(Jan 1970). (In Russian).

Tabulated data show variations of fuel element distributions and effective coefficient of breeding during flattening as functions of the number of heat transfer areas along the gradient. (8 references) (R.V.J.)

## Control Systems

*Refer also to abstract 16768.*

**18621** (HPR-111) IN-CORE MEASUREMENTS AND ACCURACIES AT HBWR. Aarset, B. (Institutt for Atomenergi, Halden (Norway). OECD Halden Reaktor Prosjekt). Jul 1969. 28p. Dep. CFSTI (U. S. Sales Only).

The in-core instrumentation developed for and used in the Halden Boiling Water Reactor is described. Operation of the on-line data processing system is discussed. Accuracy of the in-core measurements and reliability of the instrumentation are evaluated. (12 references) (M.L.S.)

**18622** (INR-1121) SOME PROBLEMS OF THERMAL PROCESSES: DYNAMIC MODEL AND DIGITAL CONTROL OF NUCLEAR REACTORS. Ciechanowicz, W. (Institute of Nuclear Research, Warsaw (Poland)). 1969. 207p. (In Polish). Dep. CFSTI (U. S. Sales Only).

The control system synthesis involves the determination of the controller structure when the information about the process is given and the control criterion is chosen. The dynamic model of the process has to be known. This model is determined on the basis of analogy between the process and model itself. However, because of the complexity of nuclear power plant processes, a number of second importance properties of the process are neglected and only those basic factors which influence the activity of a given phenomenon and are important from the control point of view are considered. This must be done not only to resolve the basic requirements with the computational possibility but also

to ensure the relationships are simple enough for analysis and simultaneously to ensure the required accuracy of the solution. There are a number of difficulties in applying the approaches of control theory to the complex systems. The main difficulties are the multidimensionality and randomness, which characterize the nuclear power plant processes. The simplifications and compromises that have to be adopted with respect to the thermal process dynamics formulation are described, and the control strategy determination to enable the practical application of modern control theory are discussed. (auth)

**18623** (LIB/Trans-250) THE EXPERIMENTAL INVESTIGATION OF A LOCAL (SPOT) HEAT TRANSFER COEFFICIENT IN THE FUEL SPACERS AREA. Vlcek, Jiri; Weber, Petr. Translated by T. A. Szentirmai (Australian Atomic Energy Commission Research Establishment, Lucas Heights), from Jad. Energ.; 14: 419-25(1968). 12p. Dep. CFSTI (U. S. Sales Only).

Results of a heat-transfer experiment in annuli with different spacers are reported. A review of this problem, derivation of basic equations, description of experimental devices, and some results are presented. The experimental data utilization and extension for both power design of nuclear reactor fuel elements and hot spot factors analyses are discussed. (auth)

**18624** IMPROVEMENTS IN OR RELATING TO THE METHOD AND MEANS OF CONTROLLING REACTIVITY IN NUCLEAR REACTORS. Hilton, Raymond Kenneth; Salter, William Bryan (to United Kingdom Atomic Energy Agency). British Patent 1,179,562. 28 Jan 1970. Filed 6 Apr 1966.

The system described is based on the concept of moving a part of the fuel within the core to bring about reactivity change. An annular blanket is provided around the core, formed by a number of fuel assemblies the latter being capable of movement away from the core so as to decouple the blanket from the core. Several arrangements of such a system are described. Biasing means may be provided for urging the blanket fuel assemblies into a decoupled position, with effective means to overcome the biasing during normal reactor operation. (UK)

**18625** APPARATUS FOR NUCLEAR REACTOR CONTROL. Siddall, E. (to Atomic Energy of Canada Ltd.). Canadian Patent 830,697. 23 Dec 1969.

A neutron absorbing liquid sometimes known as "ink" is injected into a reactor core to cause fast shutdown in about three seconds and as a means for slow controlled startup. The apparatus required consists of a U-shaped conduit disposed within the core, a reservoir containing "ink" communicating with one end of the conduit and vertically placed exterior to the core. Necessary valves and pumps for precise control of flow into and out of the reactor core are described as is a typical cycle of operation. (F.S.A.)

**18626** LIQUID METAL FAST BREEDER REACTOR INSTRUMENTATION. Feit, Ronald (Atomic Energy Commission, Washington, D. C.). IEEE (Inst. Elec. Electron. Eng.), Trans. Ind. Electron. Contr. Instr.; IECI-16: 81-93(Jul 1969).

The liquid metal fast breeder reactor (LMFBR) program is discussed with particular emphasis on the instrumentation and control elements. Near and long term requirements and their relationship to the specific project comprising the LMFBR program are outlined with respect to the current state of the art and critical problems. An overall description of the Atomic Energy Commission's LMFBR instrumentation development program is followed by a more detailed discussion of a few specific projects. The major projects and facilities related to the LMFBR instrumentation and control program are shown graphically, and discussed in detail. Among them are (1) the fast flux test facility (FFTF), a 200 MW(t) test facility currently being designed by Pacific Northwest Laboratories and scheduled to be completed in 1973. The driver core and test positions are being designed so that they can be completely instrumented. The fast flux level and temperature will be prototypical of the environment of future LMFBRs; (2) the Na pump test facility (SPTF), a 60,000 gal/min Na pump test loop currently being designed by the Liquid Metal Engineering Center and scheduled to be completed in 1971. The facility is to proof test the large Na pumps that will be required and other large components. Provision is being made to include an online calibration capability. Major projects and facilities of the LMFBR instrumentation program are the sodium components test installation (SCTI) designed to test sodium steam generators and heat exchangers. The facility will be used to test instrumentation, in conjunction with the component testing program; and the Southwest Experimental Fast Oxide Reactor (SEFOR), a 20 MW(t) test facility designed by General Electric. The facility is complete and should be operational in 1969. It was designed to study the physics characteristics of the fuels to be used in the LMFBRs. The 200 MW(e) demonstration plant programs will include sufficient instrumentation to demonstrate the design performance of all important plant components and systems as well as to aid in the prediction and diagnosis of any abnormal performance characteristics of a component of system. (BBB)

**18627** NEEDED: BETTER HARDWARE FOR NEW NUCLEAR POWER REACTORS. Feit, R.; Kelly, W. L. Contr. Eng.; 16: 65-70(Sep 1969).

Widespread use of power reactors requires designs that can optimally utilize the energy obtained from U. To this end, the USAEC is developing liquid-metal fast-breeder reactors (LMFBR's)as the next generation of nuclear power reactors. The problems entailed in the instrumentation and control of such reactors and state-of-the-art improvements that must be achieved are described. Current estimates are for capacities of about 1000 MW per commercial reactor. The difference between a fast-breeder and thermal reactor is that the fraction of delayed neutrons for the fast reactor is significantly smaller. The impact of this on control-system design is demonstrated by an examination of transfer functions that are typical for conventional reactors and LMFBR's. The higher gain of a fast-breeder reactor must be taken into account in approaching control-system design. The LMFBR's feedback coefficients which include the reactivity change due to the expansion of the fuel with temperature and the change in reactivity due to the Na density change with temperature, are also different from thermal reactors and, together with other components, require special consideration and development. Current designs call for the use of an intermediate Na loop between the reactor and steam-generating equipment, resulting in substantially longer transport lags, which must be considered when designing the overall plant-control system governing the reactor response to changes in plant load. Of two basic approaches to plant control currently being considered, one requires that the coolant flow through the reactor be held constant and the temperature difference across the reactor be varied with the change in load, and the other that the temperature difference across the reactor be held constant and the flow be varied with load changes. (BBB)

## *Shielding*

**18628** GRAPHITE MODERATED NUCLEAR REACTOR. Prince, Norman; Coast, Geoffrey (to United Kingdom Atomic Energy Authority). U. S. Patent 3,486,976. 30 Dec 1969. Priority date 8 Aug 1966, Great Britain.

The radiation top shield of a graphite moderated gas cooled reactor is separately supported on its own diagrid to take the mass of the top shield off the core structure. Preferably the top shield diagrid is suspended below and braces a steel member used to define a reentrant coolant plenum between itself and the top shield. This steel member is preferably a dome which defines between itself and the wall of the pressure vessel a heat exchanger annulus. (Offic. Gaz.)

## *Cooling Systems*

*Refer also to abstracts 16573, 16772, 16917, 17199, and 17216.*

**18629** (EURAEC-2127) STUDIES OF CYCLONES FOR STEAM SEPARATION IN BOILING-WATER REACTORS. Final Report, Part 1, January 1, 1966-September 30, 1968. Tischer (Allgemeine Elektricitaets-Gesellschaft, Frankfurt am Main (West Germany). Kernenergieanlagen). 17 Dec 1968. Contract 083-66-1-TEED. 87p. (EUR-4020; AEG-E-323-1180). Dep. CFSTI.

Work performed under United States-Euratom Joint Research and Development Program.

A study was performed on questions relating to the development of a steam separator based on gravity-type cyclones for a 160 MW(e) reactor, the tests being carried out in air/water as far as possible. This was done with a view to possible use in large nuclear power plants. Results are presented. In a 600 MW(e) project the steam separator consists of about 200 to 230 individual cyclones with an outer diameter of 170 mm, arranged radially in series in three rows. In order to pinpoint possibilities for increasing the capacity and reducing the pressure drop in the individual cyclones, air/water tests were carried out to determine the influence of certain important cyclone dimensions on the parameters carryunder, water ejection and total pressure drop. A total of nine different cyclones were measured, with different water outflow separations and separation tube and steam extraction tube diameters. (auth)

18630 (EURAEC-2132) STUDIES OF CYCLONES FOR STEAM SEPARATION IN BOILING WATER REACTORS. Quarterly Report No. 12, July 1-September 30, 1969. (Allgemeine Elektricitaets-Gesellschaft, Frankfurt am Main (West Germany). Kernenergieanlagen). 20 Nov 1969. Contract 083-66-1-TEED. 8p. (EUR-4022; AEG-E-323-1459). Dep. CFSTI.

Work performed under United States-Euratom Joint Research and Development Program.

Steam tests are considered to confirm the statements, which had been made as result of optimalization tests of steam separator cyclones in a air/water test facility. The test program is described. In air/water tests the steam outlet and the separation pipe were varied. In the considered steam experiments not only a reference cyclone but also cyclones with a reduced steam outlet and cyclones with a decreased separation pipe will be tested at a system pressure of 70 atg. The cyclone with the reduced separation pipe has a proportionally decreased steam outlet. It is intended to add three different water outlets for each of the reference cyclone and to the two varied cyclones. This will provide nine different geometries to be tested. (auth)

18631 (GEAP-10120) REACTOR PRIMARY COOLANT SYSTEM RUPTURE STUDY. Quarterly Progress Report No. 18, July-September 1969. (General Electric Co., San Jose, Calif. Atomic Power Equipment Dept.). Oct 1969. Contract AT(04-3)-189. 78p. Dep. CFSTI.

PIPES—failure of Type 304 stainless steel, Inconel 600, and carbon steel, probability analysis for
—stress analysis in metal, comparison of computer programs for
—crack growth in Type 304 stainless steel tee and carbon steel elbow, effects of stress and temperature on low cycle fatigue
—failure of boiling reactor cooling system steel, testing for low cycle fatigue
REACTORS—cooling system of, probability analysis for failure in pipes of
REACTORS, BOILING—cooling system of, low cycle fatigue testing of steel pipes for
STAINLESS STEEL—crack growth in tee shaped pipes of Type 304, effects of stress and temperature on low cycle fatigue
STEEL—crack growth in elbow shaped pipes of carbon, effects of stress and temperature on low cycle fatigue (D.C.C.)

18632 (KFK-964, Sect. 7.1-10) SOLUBILITY OF NOBLE GASES IN FLUID MEDIA. Thormeier, K. (In German).

A new experimental method is developed for determination of noble gas solubility in Na as dependent on temperature, pressure, $O_2$ concentration, C content, and time. In addition, release of gas from Na is studied. In the temperature range between 350°C and 600°C and in the pressure range from 0.5 to 4.0 Kp/cm$^2$, the Na-Ar system follows Henry's law; that means the saturation concentration is proportional to partial pressure. The method is depicted in two schematic drawings and the results are presented in two diagrams. (8 references) (H.B.G.)

18633 (KFK-964, Sect. 9.1-16) SODIUM BOILING EXPERIMENTS IN AN INDUCTIVELY HEATED TEST LOOP. Peppler, W. (In German).

Failure of the cooling system for one fuel element leads to rapid boiling of Na. The question is whether the disturbance will be limited to the particular fuel element or whether adjacent elements will be affected and damaged. To study the problem experimentally, a test loop was constructed consisting of a nickel tube one meter in length, through which Na was pumped. Heating occurred from an external high-frequency source. The arrangement allows simulation of actual heat conditions existing in a fuel element of a Na-cooled reactor. During the experiments, temperatures, pressures, fluid velocity, and power flux were recorded with a 24-channel photo printer. In addition, some of the measured values were recorded on magnetic tape for computer evaluation. In a typical experiment, Na at 580°C was pumped through the system and the microwave heating adjusted to values corresponding to those occurring in actual fuel elements. Sudden stoppage of the Na flow caused 50°C overheating of the Na and abrupt formation of steam associated with a shock wave of 10 at pressure and one msec duration. It was concluded that the shock wave has no serious damaging effects on adjacent fuel elements. Nine pictures, tables, and graphs illustrate both method and findings. (H.B.G.)

18634 (RCN-112) PRESSURIZER DYNAMICS RESPONSE TO LOAD TRANSIENTS. Van Den Honert, A. (Reactor Centrum Nederland, Petten). Dec 1969. 196p. Dep. CFSTI (U. S. Sales Only).

The various steady state and transient phenomena, occurring in a pressurized water reactor pressurizer, are described. Most of the information presented was obtained by experiments performed with a 1100 dm$^3$ pressurizer, working at a steady state pressure of 125 atm. The desired perturbations of the steady state condition were effected by a reactor simulating circuit. (133 references) (auth)

18635 (RT/ING-(69)18) FUNDAMENTALS OF REACTOR THERMOHYDRAULICS. Cumo, M. (Comitato Nazionale per l'Energia Nucleare, Rome (Italy)). [nd]. 446p. (In Italian). Dep. CFSTI (U. S. Sales Only).

Reactor Thermohydraulics collects and summarizes many aspects of the thermal and mechanical design of reactor cores and, generally speaking, of nuclear power plants. The book is subdivided in many topics which pertain to the cooling of reactor cores both of commercial and advanced plants, from the B.W.R. or P.W.R. to CIRENE reactors, from sodium cooled to steam cooled fast reactors, from Magnox to HTGR, once-through reactors, supercritical reactors and so on. Both design correlations and suggestions and trends of research and development are presented. The most recent results of research on thermohydraulics are reported, among them, original research performed in CNEN's Casaccia Laboratories. This last contribution gives to the text a greater originality and in the same time constitutes the structure on which the main results of foreign research are collected and fitted. (auth)

18636 DEVELOPMENT STATUS AND PROBLEMS OF THE SODIUM TECHNOLOGY IN THE FRG. Mausbeck, H. (Internationale Atomreaktorbau GmbH, Bensberg, Ger.). Atomkernenergie; 15: 1-13(1970). (In German). (CONF-690419-9).

From Reactor Meeting of the German Atomforum, Frankfurt am Main, Germany.

At present the sodium technology in the FRG is mainly developed in connection with the compact-sodium-reactor-experiment (KNK) and the 300 MW(e) prototype fast breeder plant (SNR). It is shown that an adequate development status is reached on the material sector and with the auxiliary Na systems. For the KNK-reactor the components of the Na loops have all been submitted to longtime performance tests in the Na test facilities. The results are discussed. The main effort of the future development is directed to the testing of the considerably larger components for the SNR. (auth)

18637 TWO-PHASE PROBLEMS IN NUCLEAR REACTORS. Mayinger, F. Atomkernenergie; 15: 47-52(1970). (CONF-690419-10).

From Reactor Meeting of the German Atomforum, Frankfurt am Main, Germany.

The primary circuit fluid in water-cooled reactors serves two purposes, one being to provide cooling and the second to serve as neutron moderator. It is in performing these functions satisfactorily and reliably that the problems in two-phase flow in nuclear reactors reside. In assessing the moderator properties of the fluid flowing through the core it is important to have accurate information on its steam quality. The determination of the steam quality presents difficulties due to sub-cooled boiling which occurs in all modern power reactors. Efficient cooling depends on an adequate heat transfer from the fuel elements surface to the fluid and on stable flow conditions in the core. Problems of critical heat flux in boiling and instabilities and pulsations in two-phase flow are discussed. (15 references) (auth)

18638 PROCEEDINGS OF CONFERENCE ON DUST COOLING, LONDON, ENGLAND, DECEMBER 1964. VOLUME 1 AND 2. London; University of London (1965). 172p. (CONF-641226-(Vol. 1 and 2)).

Research programs related to dust cooling and its application to nuclear reactors are described. The particular topics discussed include: gas suspension coolants for large reactors; design, construction, and operation of graphite gas loop; heat transfer and pressure drop characteristics of suspensions of graphite powder in $N_2$; multi-phase flow and heat transfer research at the University of California, Berkeley; simultaneous direct detection of plateout and surface temperature; heat transfer and pressure loss characteristics of $CO_2$/graphite suspensions in tubular heaters; interaction of fluid flow and mixing in fluidized beds; transfer between the bubble phase and the continuous phase of a gas solid fluidized bed; heat transfer in dense phase fluidized beds; apparatus for measuring charge magnitudes on airborne particles; Pennsylvania State University program for the measurement of Lagrangian particle motion; analog simulation and forces on a sphere; the motion of freely moving single particles; transport of micron-sized droplets to vertical surfaces; deposition of aerosols from turbulent flow through pipes; thermodynamics and heat transfer of gas-solids suspensions; and the structure of the turbulent two-phase boundary layer. (D.C.C.)

**18639** VGB-SPEISEWASSERTAGUNG 1967. (VGB Feedwater Conference 1967. Conference Held at Essen, Germany, October 17-18, 1967). Essen; VGB-Dampftechnik GmbH (1967). 74p. (CONF-671090).

Included are 10 papers on feedwater sampling and chemistry control methods. Separate abstracts were prepared for two papers dealing with coolant chemistry of water cooled reactors. (H.D.R.)

*For abstracts of individual papers see: 18517 and 18640.*

**18640** QUESTIONS WITH WATER COOLED REACTOR POWER PLANTS. Koehle, H. (Grosskraftwerk Mannheim AG, Ger.). pp 15-29 of VGB-Speisewassertagung 1967. Essen; VGB-Dampftechnik GmbH (1967). (In German).

From VGB Feedwater Conference, Essen, Germany. See CONF-671090.

Problems associated with the coolant in boiling water reactors and pressure water reactors are analyzed. Purification of the primary system with ion exchange resins and filters is described and the most important radioisotopes occurring are tabulated as to activity, neutron capture cross section, half life, and type of emitted radiation. Water treatment in the condenser is discussed. Purification of cooling water, arrangement of cooling towers, and demineralization are described. Finally, the problems involving the effluent water of a nuclear power station are analyzed. 47 references. (H.B.G.)

**18641** PRESSURE VESSEL AND PRIMARY SYSTEM MATERIALS FOR BOILING-WATER REACTORS. Hubbard, A. M. (General Electric Co., San Jose, Calif.); Cage, J. F.; Bailey, E. C. Proc. Amer. Power Conf.; 31: 242-50(1969).

From American Power Conference, Chicago, Ill. See CONF-690439.

Performance of low-alloy steel materials in pressure vessels for boiling water reactors is discussed. The operating and construction performance of the austenitic stainless steels in the cooling system are analyzed. Electroslag welding and quality control procedures for reactor cooling systems are discussed; the use of ultrasonic testing methods in reactor systems is evaluated. (M.L.S.)

**18642** OUTAGE INSPECTION OF NUCLEAR SYSTEM COMPONENTS. Anderson, T. A.; Forrer, G. R.; Hicks, I. R. (Babcock and Wilcox Co., Barberton, Ohio). Proc. Amer. Power Conf.; 31: 251-7(1969).

From American Power Conference, Chicago, Ill. See CONF-690439.

The requirements and responsibilities of the utility with regard to inspection of their nuclear steam supply equipment are outlined. The draft of the ASME Code for Inservice Inspection of Nuclear Reactor Coolant Systems is discussed; design and performance considerations are summarized. Base-line inspection and evaluation of inspection results are discussed. (M.L.S.)

**18643** HIGH-TEMPERATURE GAS-COOLED REACTOR: STEAM GENERATOR AND CIRCULATOR. Yampolsky, J. S. (Gulf General Atomic Inc., San Diego, Calif.). Proc. Amer. Power Conf.; 31: 258-67(1969).

From American Power Conference, Chicago, Ill. See CONF-690439.

The design features of the primary system components, the helium circulator, and steam generator of the Fort St. Vrain Power Reactor are described. A schematic flow diagram of the plant is shown. Design and operating conditions for the steam turbine and compressor in the primary system are tabulated. The steam generator and its installation into the integrated primary circuit are described. (M.L.S.)

**18644** FAST REACTOR CORE HEAT REMOVAL. Smidt, Dieter (Kernforschungszentrum, Karlsruhe, Ger.). Reactor Technol.; 13: 58-72(Winter 1969-70). (CONF-681101-43).

From International Conference on the Constructive Uses of Atomic Energy, Washington, D. C.

Design parameters affecting fast reactor cooling are examined. Core and cooling system design effects on power costs are described. The advantages and disadvantages of sodium, steam, and helium heat removal systems are compared, and the outlook for future developments in fast reactor cooling systems is discussed. 69 references. (H.D.R.)

## Fuels

*Refer also to abstracts 16486, 16625, and 16666.*

**18645** (CONF-690910-, pp 59-70) XENON TAGGING OF INSTRUMENTED FUEL CAPSULES FOR USE IN EBR-II. Walker, D. E.; Halfman, P. J.; Sanecki, J. H. (Argonne National Lab., Ill.).

An instrumented subassembly for the EBR-2 is described. The sensors in the subassembly provide signals for: fuel-center temperatures up to 2000°C; cladding temperature; fuel-element internal pressure; Na inlet and outlet temperatures; Na flow rate; and neutron flux. The subassembly contains 19 elements and 22 instrument leads. To permit rapid and positive indication that the subassembly contains a failed or defected fuel element, each element is tagged by approximately 1 ml of a gas containing mixture of xenon isotopes to the He bond gas. The resulting gas mixture consists of approximately 14 vol. % of Xe in He. If an element should fail, the tag gas would be liberated to the reactor's Ar cover gas where it would be detected. (D.C.C.)

**18646** (CONF-690910-, pp 71-102) INSTRUMENTED SUBASSEMBLY SYSTEM AND IN-CORE INSTRUMENT TEST FACILITY FOR EBR-II. Hutter, E.; Seim, O. S.; Smaardyk, A. (Argonne National Lab., Ill.).

The design parameters of the EBR-2 are reviewed. The control and loading systems are described. The design parameters for the instrumented subassembly are presented. The subassembly consists of 16 capsules containing Type 304 stainless steel clad $UO_2$ fuel specimens and two capsules containing structural materials. 6 references. (D.C.C.)

**18647** (CONF-690910-, pp 103-17) CHARACTERIZATION OF ADVANCED IRRADIATION TESTING VEHICLES FOR EBR-II. Seim, O. S.; Ware, W. R.; Hutter, E. (Argonne National Lab., Ill.).

Experimental facilities for the EBR-2 are described. Design parameters and illustrations are presented for various fuel elements involved in radiation testing experiments. (D.C.C.)

**18648** (IAE-1833) THEORETICAL MODEL OF THE FOULING PROCESS IN THE CORES OF ORGANIC COOLANT REACTORS. Aleksenko, Yu. N.; Mukhina, G. V. (Akademiya Nauk SSSR, Moscow. Institut Atomnoi Energii). 1969. 19p. (In Russian). Dep. CFSTI (U. S. Sales Only).

The formation of insoluble deposits on the surface of the fuel elements of an organic coolant reactor is analyzed on the basis of the diffusion boundary layer theory proposed by V. G. Levich and a picture of the formation of coke in stages. The correctness of this model and its utility as a theoretical basis for further research is shown by comparing the relationships thus obtained with experimental data. (6 references) (auth)

**18649** (KFK-964, Sect. 2.1-11) A METHOD FOR COMPUTING THE STRENGTH OF FUEL ELEMENT CLADDING FOR SODIUM-COOLED FAST BREEDER REACTORS. Schmidt, G. (In German).

A new method for calculating mechanical properties of austenitic stainless steel canning for fuel elements is presented which allows solution of the creep problem and thermal stress. Results are presented in seven diagrams. (8 references) (H.B.G.)

**18650** (KFK-964, Sect. 3.1-15) STRUCTURAL EXPANSION AND DISTORTION IN FAST REACTORS. Hoang, Y. S. (In German).

Bending effects of fuel elements are theoretically studied under the influence of temperature and spacial arrangement. Also calculated are the occurring tensions and changes of reactivity due to distortions of neutron flux. The mathematical considerations are then applied to a Na-cooled reactor. Optimal spacial arrangement of fuel elements and type of their fixation are derived. Results are graphically presented in seven diagrams. (11 references) (H.B.G.)

**18651** (KFK-964, Sect. 4.1-15) STUDIES OF FUEL ELEMENT OSCILLATIONS CAUSED BY HYDRODYNAMIC FORCES OF THE COOLING MEDIUM. Kadlec, J. (In German).

Oscillations of fuel elements in a fast breeder reactor caused by the cooling fluid are theoretically analyzed. From the mathematical considerations, a computer program is developed for the IBM 7074. To verify the computations, eigenfrequencies of fuel elements are determined experimentally by induction of oscillations with an electromagnetic device. Agreement between theory and experimental data is excellent. Experimental procedures and findings are documented by seven diagrams. (6 references) (H.B.G.)

**18652** (KFK-964, Sect. 5.1-12) VELOCITY AND TEMPERATURE DISTRIBUTION AS WELL AS THERMAL STABILITY WITHIN CLOSELY PACKED ASYMMETRICALLY ARRANGED FUEL ELEMENTS. Fischer, M.; Shimamune, H. (In German).

In high power breeder reactors, fuel elements are closely packed. Therefore, minor deviations in distance and distribution of fissionable material cause significant distortions in velocity and heat exchange of the cooling medium. Consequently, localized temperature differences develop within fuel elements which cause thermal bending. Mathematical methods are developed for computation of velocity and temperature distribution in a turbulent cooling fluid through asymmetrically arranged fuel elements. The theoretical findings are depicted graphically in six diagrams. (H.B.G.)

**18653** (KFK-964, Sect. 10.1-14) RADIATION EXPERIMENTS FOR DEVELOPMENT OF FAST BREEDER REACTOR FUEL ELEMENTS. Bojarsky, E. (In German).

Development of optimum fuel elements for fast breeder reactors requires extensive testing under high neutron flux. The various possibilities for such experimental loops are discussed with respect to existing facilities in Germany, Belgium, and England. The study serves as a preliminary to a detailed experimental program. Flow diagrams for helium loops and heavy-water loops as well as cross sections of the samples to be irradiated are depicted on six pages. (H.B.G.)

**18654** (KFK-1028) EXPERIMENTAL INVESTIGATION OF THE LOSS OF PRESSURE AND OF THE LONG-TERM BEHAVIOR OF THE REINFORCED PLACE IN A MODEL FUEL ELEMENT WITH AN INCOLOY 800 TUBE WITH SIX INTEGRAL SPIRALS AS SPACERS IN AN ISOTHERMAL STREAM OF SUPERHEATED STEAM. Hoffmann, H.; Hofmann, G.; Leistikow, S. (Kernforschungszentrum, Karlsruhe (West Germany)). Sep 1969. 68p. (In German). (EUR-4304). Dep. CFSTI (U. S. Sales Only).

As fuel elements for fast breeder reactors, Incoloy-800 tubes with spirals serving as cooling fins and spacers are presently under consideration. To study the behavior of such elements under simulated operating conditions a model with 37 fuel element bundles was constructed and was tested up to 500 hours with isothermal steam of 505°C, 130 atm pressure, and Reynold numbers ranging from 65,000 to 220,000. After conclusion of the test, the elements were studied as to metal loss through oxidation and deformation of the cooling fins. It was concluded that the spiral arrangement is suitable for steam-cooled reactors. (H.B.G.)

**18655** (ORNL-4480, pp 59-69) LMFBR FUEL ELEMENT DESIGN AND MODEL DEVELOPMENT. (Oak Ridge National Lab., Tenn.).

From Fuels and Materials Development Program Quarterly Progress Report.

Analytical methods for predicting performance characteristics of LMFBR fuel rods and fuel elements are outlined. Models for analysis of mechanical interaction between fuel and cladding, swelling of cladding caused by fast neutron fluence, and clad failure caused by crack propagation are described briefly. (M.L.S.)

**18656** (ORNL-TM-2743) DESIGN AND CONSTRUCTION OF CORE IRRADIATION-SPECIMEN ARRAY FOR MSRE RUNS 19 AND 20. Gabbard, C. H. (Oak Ridge National Lab., Tenn.). 22 Dec 1969. Contract W-7405-eng-26. 23p. Dep. CFSTI.

A new MSRE core specimen array was designed and fabricated to replace the type of metallurgical surveillance specimen array that was used in the MSRE through Run 18. The main purpose of the new array is to measure the capture-to-absorption ratio of $^{233}U$ and to determine the effects of salt velocity, turbulence, and surface finish on the deposition of fission products on graphite and on Hastelloy-N. Two additional test specimens were included, one of pyrolytic graphite to determine if there is permeation of fuel salt or its constituents into the graphite and one of Hastelloy-N to expose a series of electron microscope screens in a trapped gas pocket. The new specimen array was installed on July 31, 1969 and was exposed in the reactor core for 12,943 MWhrs of reactor operation during Runs 19 and 20. (auth)

**18657** CISE ACTIVITIES FOR THE CIRENE REACTOR FUEL DEVELOPMENT. Scaroni, A. (CISE, Milan). Energ. Nucl. (Milan); 16: 755-63(Dec 1969). (In Italian).

The basic design parameters of the CIRENE fuel elements are summarized. Facilities and procedures employed in fabrication of the elements are described. Present and planned future activities in fuel development are discussed. (H.D.R.)

**18658** HIGH BURNUP IRRADIATION EXPERIENCE IN VULCAIN. Storrer, J. (BelgoNucleaire, Brussels); Locke, D. H. Nucl. Eng. Int.; 15: 93-9(Feb 1970).

The BR3/Vulcain PWR core was examined after average and maximum burnups of 24,000 and 50,000 MWd/teU respectively. Operational details are given of the reactor both as a conventional PWR and during the high burnup experiment. Procedure during discharge and inspection of the fuel elements is described and some post-irradiation examination data are presented. The future program is outlined. (UK)

**18659** ECONOMIC FACTORS AFFECTING THE CHOICE OF FUEL FOR A LIQUID METAL-COOLED FAST BEEDER REACTOR. Dyos, M. W.; Thomas, K. C.; Hauger, S. E. (Westinghouse Electric Corp., Madison, Pa.). Proc. Amer. Power Conf.; 31: 150-4(1969).

From American Power Conference, Chicago, Ill. See CONF-690439.

The oxide and carbide fuel concepts are compared for the LMFBR with respect to fuel doubling times and fuel cycle costs. Possible fuel rod design parameters are tabulated. Economic effects of doubling time, fuel inventory and credit, and spent fuel shipping and reprocessing are discussed. (M.L.S.)

**18660** FUEL CONSIDERATIONS. Sebilleau, F. (CEA, Fontenay-aux-Roses, France). Reactor Technol.; 13: 54-7 (Winter 1969-70). (CONF-681101-42).

From International Conference on the Constructive Uses of Atomic Energy, Washington, D. C.

The burnup characteristics of oxide and carbide fast reactor fuels as determined in irradiation programs are summarized. Problems with fission gas release, swelling, and canning materials are described. Values of linear power investigated for various fuels are discussed, and factors affecting the limiting values are examined. 6 references. (H.D.R.)

**18661** CANNING MATERIALS FOR FAST REACTOR FUEL RODS. Lagerberg, Goeran; Egnell, Lennart (Sandvik Steelworks, Sweden). Nucl. Eng. Int.; 15: 203-7(Mar 1970).

Mechanisms of deterioration are discussed as well as physical and mechanical qualities required by materials formulated to withstand the very high, integrated fast neutron flux irradiation doses experienced in FBR cores. A 15% Cr-15% Ni austenitic stainless steel with Mo, Ti and B additions, developed for such service, is described. (auth)

**18662** PROSPECTIVE TECHNICAL-ECONOMIC AND PREDICTABLE DEVELOPMENT OF THE NUCLEAR FUEL CYCLE. Angelini, A. M. pp 35-64 of Utilizzazione del Combustibile Nucleare. Roma; Comitato Nazionale Energia Nucleare (1969). (In Italian).

From 10th International Nuclear Energy Conference, Milan, Italy. See CONF-681219.

Technical and economic evolution of the nuclear fuel cycle has made a decisive contribution to the development of nuclear energy. Progress made in the past and the prospects of further development and the predictable evolution of the main elements determining the economics of nuclear fuels are: the cost and availability of primary raw materials; the processes of conversion and fabrication by which the raw materials are processed into fuel elements — in particular, the isotopic separation processes for the enriched-uranium reactors; the characteristics of the various types of reactors, such as condition and performance of the fuel elements; and the chemical separation processes for the reprocessing of irradiated fuels. The prospects of industrial application of the recycling of plutonium in thermal reactors and the predictable evolution of breeder reactors are discussed. (auth)

**18663** RECYCLE OF PLUTONIUM FROM THERMAL REACTORS. Sani, L. pp 183-207 of Utilizzazione del Combustibile Nucleare. Roma; Comitato Nazionale Energia Nucleare (1969). (In Italian).

From 10th International Nuclear Energy Conference, Milan, Italy. See CONF-681219.

The main interest of the recycling of plutonium in thermal reactors, pending for the advent of fast reactors, lies unquestionably in two possibilities: on the one hand, the use of plutonium as a fissionable material in lieu of $^{235}U$ as an alternative to enriched uranium, and on the other the increased utilization of the source material. For certain reactors, both of proven design and of advanced converter type, the index of utilization of the natural uranium in MWye/ton U nat is analyzed. A comparison of these indices makes it evident that the recycling of plutonium in thermal reactors, if adopted on a large scale, would result in a 30 to 50% reduction in the demand for natural uranium for the production of enriched uranium. The problems arising from the use of plutonium, both from the strictly nuclear aspect and from that of the technological aspect connected with fuel element fabrication, are described. The differences in neutronic properties between plutonium and uranium and the problems encountered in the nuclear designing of such fuels are presented. Problems related to $PuO_2$-$UO_2$ mixtures are analyzed. Problems related to recycling of plutonium in thermal reactors are described (7 references) (auth)

**18664** PLUTONIUM RECYCLE FOR PRESSURIZED WATER REACTORS. Bonanni, M. (Westinghouse International Atomic Power Co., Ltd., Geneva); Forscher, F.; Roll, J. B. pp 209-28 of Utilizzazione del Combustibile Nucleare. Roma; Comitato Nazionale Energia Nucleare (1969).

From 10th International Nuclear Energy Conference, Milan, Italy. See CONF-681219.

Pressurized water reactors have been sold throughout the world based on large measure on competitive evaluation of total power costs. These evaluations assume the successful recovery and utilization of the plotonium generated during each reactor cycle, and thus a plutonium credit is taken in the evaluation of the fuel cycle economics. Until the advent of the economic fast breeder reactor and its widespread commercial application, the only use for Pu in large quantities will be in thermal reactors. Thus, to ensure that this plutonium value can be achieved and that the power costs presently being forecasted are actually realized, a commercial plutonium recycle demonstration program has been initiated. The evolution and program planning over the past two years are described. The technical results of the programs now in progress are summarized. (6 references) (auth)

**18665** HOW TO MEET EUROPEAN REQUIREMENTS FOR NUCLEAR FUEL REPROCESSING. Rometsch, R. (EUROCHEMIC, Mol, Belg.). pp 319-33 of Utilizzazione del Combustibile Nucleare. Roma; Comitato Nazionale Energia Nucleare (1969).

From 10th International Nuclear Energy Conference, Milan, Italy. See CONF-681219.

The nuclear fuel reprocessing capacity offered covers at least twice the present requirements. European programmes for construction and operation of proven-type reactors, mainly light water reactors, show that around the middle of the seventies this capacity would no longer be sufficient. Extension requirements are described. Problems related to the development of an economic and efficient reprocessing capability are analyzed. (4 references) (auth)

**18666** TONS OF CURIUM AND POUNDS OF CALIFORNIUM. Crandall, J. L. (E. I. du Pont de Nemours and Co., Aiken, S. C.). pp 193-203 of The International Conference on Constructive Uses of Atomic Energy. /Farmakes, Ruth (ed.). Hinsdale, Ill.; American Nuclear Society (1969).

From International Conference on the Constructive Uses of Atomic Energy, Washington, D. C. See CONF-681101.

The recovery of actinides from spent power reactor fuels is discussed. Effects of reactor types and fuel cycle management on production rates are analyzed. Particular actinides described include: $^{241}Am$, $^{243}Am$, $^{252}Cf$, $^{244}Cm$, $^{237}Np$, and $^{231}Pa$. 44 references. (D.C.C.)

**18667** COMMENTARY ON TONS OF CURIUM AND POUNDS OF CALIFORNIUM. Errington, R. F. (Atomic Energy of Canada Ltd., Ottawa). pp 204-6 of The International Conference on Constructive Uses of Atomic Energy. /Farmakes, Ruth (ed.). Hinsdale, Ill.; American Nuclear Society (1969).

From International Conference on the Constructive Uses of Atomic Energy, Washington, D. C. See CONF-681101.

Economic prospects for utilizing actinides produced in power reactor fuels are presented. (D.C.C.)

**18668** FUEL CONSIDERATIONS. Sebilleau, F. (Commissariat a l'Energie Atomique, Fontenay-aux-Roses, France). pp 361-4 of The International Conference on Constructive Uses of Atomic Energy. /Farmakes, Ruth (ed.). Hinsdale, Ill.; American Nuclear Society (1969).

From International Conference on the Constructive Uses of Atomic Energy, Washington, D. C. See CONF-681101.

Burnup and heat rating values for different types of fast reactor fuels are compared. The comparisons are presented for metal alloys, carbides, and oxides. 6 references. (D.C.C.)

**18669** FAST REACTOR CORE HEAT REMOVAL. Smidt, Dieter (Kernforschungszentrum, Karlsruhe, Ger.). pp 365-79 of The International Conference on Constructive Uses of Atomic Energy. /Farmakes, Ruth (ed.). Hinsdale, Ill.; American Nuclear Society (1969).

From International Conference on the Constructive Uses of Atomic Energy, Washington, D. C. See CONF-681101.

Coolant performance for $PuO_2$–$UO_2$ fueled fast reactors is analyzed. Heat transfer characteristics of gas, liquid Na, and steam are compared. 69 references. (D.C.C.)

**18670** STUDY OF A SYSTEM FOR THE REPLACEMENT OF FUEL ELEMENTS FOR AN ORGANIC COOLED AND MODERATED REACTOR WITH THE LOADING MACHINE CONTAINED INSIDE THE PRESSURE VESSEL. Carmignani, C.; Guerrini, B. Ing. Nucl.; 10: No. 5, 9-18(Sep-Oct 1969). (In Italian).

A proposed design for a fuel element loading machine for the organic cooled and moderated ROVI reactor is described. The operation of the loading machine, which is to be situated inside the pressure vessel, is discussed. Schematics and cutaways show details of the proposed system. Problems associated with the proposed machine are considered. (M.L.S.)

## *Auxiliary and Emergency Systems*

*Refer also to abstracts 16758 and 17217.*

**18671** (ANL-7585) MECHANICAL IMPROVEMENTS OF THE EBR-II FUEL UNLOADING MACHINE. Waldo, James B. (Argonne National Lab., Ill.). Nov 1969. Contract W-31-109-eng-38. 52p. Dep. CFSTI.

The EBR-II fuel unloading machine (FUM) transfers all reactor subassemblies between the Na-filled primary tank and the interbuilding coffin. The machine is basically a self-propelled shield cask, which moves on rails between the primary-tank transfer port and the interbuilding-coffin pit. The FUM control panel and most of the mechanical equipment are located at the top of the shield cask. A subassembly gripper mechanism in the machine can be extended downward, through the shielding, into the primary-tank transfer port or into the interbuilding coffin to insert or remove a reactor subassembly. An automatic Ar-circulating system provides subassembly cooling or heating and Na blow-off capabilities while the subassembly is being handled by the FUM. The mechanical changes and improvements, made to the FUM since the original design, are described. These changes have evolved from continuous surveillance and engineering evaluation of the problems that have occurred with the machine during normal fuel handling. (auth)

## *Operation and Economics*

*Refer also to abstracts 18523 and 18749–18751.*

**18672** (CEA-CONF-1478) REACTORS G.2/G.3: PERFORMANCES OF THE PRINCIPAL PARTS AFTER 10 YEARS OF OPERATION. Conte, F. (Commissariat a l'Energie Atomique, Chusclan (France). Centre de Production de Plutonium de Marcoule). [nd]. 16p. (In French). (CONF-691115-4). Dep. CFSTI (U. S. Sales Only).

From Symposium on the Performance of Nuclear Power Reactor Components, Prague, Czechoslovakia.

The principal components of the Marcoule G-2 and G-3 reactors are described and a brief history of their performance is presented. The components described include: turboalternators, blowers, cladding rupture detection system, core structures, graphite, control rods and drives, fuel handling system, prestressed concrete vessels, piping, secondary cooling system, heat exchangers, and nuclear instrumentation. The power production, plant availability, unplanned shutdowns, and principal causes of shutdowns are tabulated. (H.D.R.)

**18673** (KFK-964, Sect. 11.1-11) CALCULATING THE BUILDING COST OF PROJECTED NUCLEAR POWER STATIONS USING ELECTRONIC COMPUTERS. Mueller, A.; Schmidtborn, I.; Schramm, K. (In German).

For an IBM computer 7074 a program is developed for a reasonable assessment of the building costs of projected nuclear power stations. As an example, price calculations for a given heat exchanger are discussed. Flow rate, pressure, and temperature for the primary and secondary cooling circuits are inserted into the computer program. The computer then determines the necessary heating surface, dimension of heat exchange tubes, and both volume and weight of the pressure vessel. These values, in turn, are transferred to a cost function that finally yields to cost of the heat exchanger including testing and installation at the power station. Generally, total building costs can be computed within 7% of actual values. Thus, the program allows the selection of the most economic installation among several proposals. (H.B.G.)

**18674** (NP-18148) O.E.C.D. HIGH TEMPERATURE REACTOR PROJECT (DRAGON). Tenth Annual Report, 1968–1969. (Organization for Economic Co-operation and Development, Paris (France)). 175p. Dep. CFSTI (U. S. Sales Only).

CARBON — radiation effects on coatings of pyrolytic, neutron
FISSION PRODUCTS — release to Dragon coolant during operation, (E)

GRAPHITE—radiation effects on dimensional changes in, neutron
HEAT EXCHANGERS (GAS-LIQUID)—operation of Dragon reactor, corrosion and fretting problems in
HIGH-TEMPERATURE GAS-COOLED REACTOR EXPERIMENT—operation during April 1968 to March 1969
—maintenance during April 1968 to March 1969
—fission product release measurements during operation of
—coolant sampling in, diffusion tube probe for
—heat exchangers for, corrosion problems in
—reactivity history of charge 3 in
—fuel irradiation testing in, summary of April 1968 to March 1969
—physics measurements in
—fuel cycle development for
—fuel element design for
—heat exchangers for, fretting tests on
NEUTRONS—effects on dimensional changes of graphite and coatings of pyrolytic carbon
REACTOR FUEL ELEMENTS—design for high temperature gas cooled reactors
—radiation testing of Dragon
REACTOR FUELS—radiation testing of coated particle
—coating development for particle type
—cycles for high temperature gas cooled reactors, development of optimum (H.D.R.)

**18675** (NP-18149) OECD HALDEN REACTOR PROJECT. Ninth Annual Report, 1968. (Organization for Economic Co-operation and Development, Paris (France)). 179p. Dep. CFSTI (U. S. Sales Only).

ALUMINUM—corrosion testing in Halden reactor cooling system
HALDEN BOILING REACTOR—operation of, summary of 1968
—control system for, development of direct digital computer
—neutron flux in, measurement of fast
—fuel irradiation testing in, summary of 1968
—instruments for, development of in-core
—cooling system of, distribution of iodine in primary
—cooling system of, corrosion of metal specimens in primary
IODINE—distribution in Halden reactor cooling system following fuel failure
NEUTRONS, FAST—flux measurements in Halden reactor core
REACTOR CONTROL SYSTEMS—performance of Halden digital computer, during 1968
REACTOR FUEL ELEMENTS—radiation testing in HBWR, summary of 1968
—radiation testing of, development of in-core instruments for
STAINLESS STEEL—corrosion testing in Halden reactor cooling system
STEEL—corrosion testing in Halden reactor cooling system
ZIRCALOY-2—corrosion testing in Halden reactor cooling system (H.D.R.)

**18676** (NP-18157) TECHNICAL PROPERTIES OF THERMAL POWER STATIONS INFLUENCING THE POWER SYSTEM'S OPERATION. (Statens Vattenfallsverk, Stockholm (Sweden)). May 1969. 215p. (In Swedish). Dep. CFSTI (U. S. Sales Only).

A survey of the working properties is presented for fossile fueled steam power plants, gas turbine plants, and nuclear plants at normal conditions, start-up, and disturbances. Some data are presented for the Marviken and Oskarshamn nuclear plants and for the PWR and BWR plants which are being considered for installation. (Sweden)

**18677** (ORNL-4449, pp 1-38) MOLTEN-SALT REACTOR EXPERIMENT. Haubenreich, P. N. (Oak Ridge National Lab., Tenn.).

FISSION PRODUCTS—deposition in MSRE, γ spectrometer for measurement of
GAMMA SPECTROMETERS—use for fission product measurements in MSRE
GRAPHITE—radiation effects on, fast neutron
MOLTEN SALT REACTOR EXPERIMENT—operation during March through August 1969
—maintenance during March through August 1969
—reactivity balances during uranium-233 operation
—reactivity effects of graphite distortion in
—fuel for, effect of pump speed on gas in
—fuel for, cover gas solubility effects on bubbles in
—xenon poisoning in, effect of core void fraction on
—fuel system for, fission product distributions in
—components for, thermal cycle history of
—control rod and drive assemblies for, scram time testing of
—physics analysis for uranium-235 fueled, revised average reaction cross sections from
—fuel for, revised burnup coefficients for uranium isotopes in
—plutonium production during uranium-235 fueled operation of
—fuel system for, inspection of freeze flanges in
—fuel system for, operation of circulation pump in
—fission product deposition in, remote γ spectrometer for measurement of
—fuel for, noble metal migration in
—control system for, modification of
—cover gas entrainment in fuel of, use of noise analysis for monitoring of
NEUTRONS, FAST—effects on graphite dimensional changes
PUMPS—operation of MSRE fuel circulation
REACTOR CENTRAL SYSTEMS—design of MSRE, modification of
REACTOR FUELS—noble metal migration in MSRE (H.D.R.)

**18678** EBR-2 AS A FAST REACTOR IRRADIATION FACILITY. Kirn, Frederick S. (Argonne National Lab., Idaho Falls, Idaho). Nucl. News; 13: No. 3, 62-8(Mar 1970).

The Experimental Breeder Reactor-2 is being used in a test program to help characterize the irradiation properties of fast reactor fuels and materials in a sodium-cooled fast breeder reactor environment. The overall reactor design is described and the experimental irradiations history is tabulated. Transitions in the physical and neutronics characteristics of the EBR-2 are described, and plans for future utilization of the facility are presented. (H.D.R.)

**18679** OPTIMAL FUEL REPLACEMENT IN REACTIVITY LIMITED SYSTEMS. Fagan, John R.; Sesonske, Alexander (Purdue Univ., Lafayette, Ind.). J. Nucl. Energy; 23: 683-96 (Dec 1969).

As a step in the development of an optimal fuel replacement scheme for a large pressurized water reactor, it was shown that the operating parameters and constraints for individual fuel subassemblies can be expressed in terms of one time dependent parameter, burnup, as long as the gross neutron flux distribution does not change radically with time. The required constraints on the empirical model are therefore adequately satisfied for the intuitively attractive case of scatter (or Roundelay) refueling. As a result, it was possible to investigate analytically a "quazi-equilibrium" cycle for both direct replacement and shuffle refueling. Whereas direct replacement showed little advantage over the equilibrium cycle, shuffling of the fuel to a more optimum configuration at each fuel replacement cycle indicated potential savings of several hundred thousands of dollars a year for a 1000 MW(e) pressurized water plant. (auth)(UK)

**18680** OPTIMIZATION OF BWR FUEL MANAGEMENT USING AN ACCELERATED EXHAUSTIVE SEARCH ALGORITHM. Stover, Roger L.; Sesonske, Alexander (Purdue Univ., Lafayette, Ind.). J. Nucl. Energy; 23: 673-82(Dec 1969).

Using an alternative to dynamic programming, optimum fuel cycle costs of a three-zone, scatter-loaded nuclear power reactor can be found with nominal computer memory and time requirements. The optimization algorithm, called Elimination of Similar End States, is an accelerated exhaustive search technique. Application to a BWR core model yielded a non-uniform loading strategy with a fuel cycle cost 5 to 6% lower than for a reference, uniform loading scheme. (auth)(UK)

**18681** SEFOR STARTUP AND INITIAL OPERATION. Arterburn, J. O. (General Electric Co., Fayetteville, Ark.). Proc. Amer. Power Conf.; 31: 144-9(1969).

From American Power Conference, Chicago, Ill. See CONF-690439.

A general description of the startup and initial operation of SEFOR is given. Preoperational testing of the conventional and sodium systems and the refueling cell is described. The initial fuel loading process, which was underway at the time of this article, is described. (M.L.S.)

**18682** HIGH-TEMPERATURE REACTORS. Rennie, C. A. (Atomic Energy Establishment, Winfrith, Eng.). pp 77-86 of The International Conference on Constructive Uses of Atomic Energy. /Farmakes, Ruth (ed.). Hinsdale, Ill.; American Nuclear Society (1969).

From International Conference on the Constructive Uses of Atomic Energy, Washington, D. C. See CONF-681101.

Brief reviews of operation experiences for Dragon Reactor, AVR Reactor, and Peach Bottom Power Reactor Unit 1 are presented. Development programs described include: fuel cycles; fuel elements; coated particles; fuel handling; fuel performance; and safety. (D.C.C.)

18683 MOLTEN SALT REACTORS. MacPherson, H. G. (Oak Ridge National Lab., Tenn.). pp 111-21 of The International Conference on Constructive Uses of Atomic Energy. /Farmakes, Ruth (ed.). Hinsdale, Ill.; American Nuclear Society (1969).

From International Conference on the Constructive Uses of Atomic Energy, Washington, D. C. See CONF-681101.

Operating experiences of the MSRE are reviewed. Typical fuel requirements for molten salt-fueled reactors are described. 4 references. (D.C.C.)

## Safety and Siting

18684 (AI-AEC-12792(Vol.3)) 1000-Mwe LIQUID METAL FAST BREEDER REACTOR FOLLOW-ON STUDY. TASK III REPORT. CONCEPTUAL DESIGN REPORT, PLANT SAFETY ANALYSES. VOLUME III. PLANT SAFETY ANALYSES. Harper, B. E.; Hart, R. S. (eds.) (Atomics International, Canoga Park, Calif.). [1968]. Contract ANL 31-109-38-1996. 176p. Dep. CFSTI.

For Argonne National Lab., Ill.

Safety analyses of the Atomics International conceptual design for a 1000 MWe LMFBR. Safety criteria are listed; analyses are included for the following types of accidents: loss of coolant flow, guillotine pipe rupture, out-of-core fuel handling, sodium fire, plugged coolant channel, control rod ejection, and gas bubbles in core. A detailed containment and site radiological evaluation is also included. (M.L.S.)

18685 (BMI-1874) FISSION-PRODUCT DEPOSITION AND ITS ENHANCEMENT UNDER REACTOR ACCIDENT CONDITIONS: DEVELOPMENT OF REACTIVE COATINGS. One of Three Separate Final Reports on Task 3. Rosenberg, Harvey S.; Cremeans, George E.; Genco, Joseph M.; Berry, David A.; Morrison, David L. (Battelle Memorial Inst., Columbus, Ohio). Nov 1969. Contract W-7405-eng-92. 61p. (EURAEC-2133). Dep. CFSTI.

Work Performed under United States-Euratom Joint Research and Development Program.

Various amine-containing polymers were studied in steam-air environments at elevated temperatures using dilute quantities of $^{131}I$-tagged iodine. Both noncondensing and condensing steam conditions were investigated. Several of the polymers showed sorption rates and capacities that would be adequate for the chemical removal of accident-released fission-product iodine and were several times more effective than commercial protective coatings currently being used. Some of the polymers also showed excellent resistance to loss-of-coolant accident environmental conditions on steel and concrete substrates. The retentive coating recommended for steel is a binder consisting of 90 w/o DMAM-10 w/o Epon 828 mixed with 50 w/o $TiO_2$ pigment and applied over an iron oxide primer. The coating recommended for concrete is a 50 w/o Genamid 2000-50 w/o Epon 828 binder mixed with 50 w/o $TiO_2$ pigment and applied over as-cured, job-placed concrete. The DMAM coating was subjected to two large-scale proof tests in the Aerosol Decontamination Facility and yielded half-lives of 1 and 16 min for the airborne $I_2$ and $CH_3I$ concentrations, respectively, and maintained its integrity during the experiments. The use of a reactive coating as a passive safety system should appreciably reduce the airborne iodine half-life and the hazards associated with iodine release during a nuclear reactor accident. (27 references) (auth)

18686 (GEAP-5348) EVESR RADIOACTIVITY TRANSPORT AND DEPOSITION. Meek, M. E. (comp.) (General Electric Co., Sunnyvale, Calif. Breeder Reactor Development Operation). Jun 1967. Contract AT(04-3)-189. 142p. Dep. CFSTI.

Results of the activity deposition program in the Vallecitos Superheat Reactor are detailed. Activity was introduced into the cooling system via machined slots in the fuel element cladding. Reactor operation prior to use of defective fuel is summarized; iodine and noble gas fission product activities in the primary and secondary systems are tabulated. Plant operation and shutdown radiation levels are then detailed for each fission product defect introduced. Contamination levels are described for each of the loops in the cooling system. (M.L.S.)

18687 (KFK-964, pp Sect. 8.1-12) EXPERIMENTAL STUDIES OF INCIPIENT-BOILING OF SODIUM. Schultheiss, G. F. (In German).

The boiling delay of liquid Na is studied in a specially designed experimental arrangement of which two diagrams are given. Fifty thermocouples measure temperatures at various points of the equipment and a piezo-electric device measures the pressure. The data are recorded by a 12-channel printer. Generally, boiling delay decreases with increasing sodium oxide content. Solution of argon has no noticeable effect on the boiling point of Na. It is concluded that in Na-cooled fast breeder reactors no striking boiling delay should be anticipated. Results are presented in four diagrams. (7 references) (H.B.G.)

18688 (ORNL-TM-2774) PRELIMINARY EVALUATION OF THE FIRST FUEL ROD FAILURE TRANSIENT TEST OF A ZIRCALOY-CLAD FUEL ROD CLUSTER IN TREAT. Lorenz, R. A.; Parker, G. W.; Hobson, D. O. (Oak Ridge National Lab., Tenn.). 26 Nov 1969. Contract W-7405-eng-26. 47p. Dep. CFSTI.

The first fuel rod failure experiment in TREAT was performed September 12, 1969. The test was conducted as planned: all rods ruptured and fission products from the preirradiated center rod were collected on the two fission product collection systems. Only preliminary data are available from the post-experiment examination. Fission heating in the $UO_2$ pellets raised the Zircaloy cladding temperature of the 7-rod bundle 72°F/sec for about 20 sec. A variety of fuel rod construction including two clad alloys, different plenum volumes, different pellet-to-cladding clearances, and internal pressures ranging from 115 to 215 psia (77°F) were used. The bundle was removed from its capsule and photographed in the hot cell. Photographs were taken of the bundle and of the individual rods after removal from their supports. Estimations of cooling channel blockage made from the photographs showed a maximum of approximately 58% blockage. The TREAT fuel rod failure tests utilize $UO_2$ pellets as the uniquely realistic heat source to duplicate precisely the internal heat transfer characteristics of actual power reactor fuel rods. (auth)

18689 MULTIBARRIER CONTAINMENT. Corcoran, R. W.; Claeson, E. U.; Newhart, L. E. (Pioneer Service and Engineering Co., Chicago). Proc. Amer. Power Conf.; 31: 231-41(1969).

From American Power Conference, Chicago, Ill. See CONF-690439.

The multibarrier containment concept for nuclear power plants is discussed. The primary and secondary containment systems are described; penetrations, the shield building vent system, containment vessel isolation systems, and auxiliary building vent systems are considered. (M.L.S.)

18690 ANALYSIS OF THE SAFETY OF A NUCLEAR PLANT. METHODS OF ASSURANCE. Galvagni, Remo (CNEN, Rome). Ing. Nucl.; 10: No. 5, 19-24(Sep-Oct 1969). (In Italian).

Methods for evaluating the safety of nuclear power plants are discussed. Criteria for component classification and examples of this categorization are outlined. Criteria for classification of protective systems are listed. Application of the criteria to plant safety analyses is discussed. (M.L.S.)

18691 NEW METHODS AND TECHNIQUES IN NUCLEAR SAFEGUARDS RESEARCH AND DEVELOPMENT. Keepin, G. Robert (Los Alamos Scientific Lab., N. Mex.). pp 152-60 of The International Conference on Constructive Uses of Atomic Energy. /Farmakes, Ruth (ed.). Hinsdale, Ill.; American Nuclear Society (1969).

From International Conference on the Constructive Uses of Atomic Energy, Washington, D. C. See CONF-681101.

Development programs related to improved techniques in nuclear materials monitoring are described. Techniques discussed include: passive and active interrogation; parallel computational programs; detectors and sources; and practical assay applications. 13 references. (D.C.C.)

18692 SAFEGUARDS SYSTEM STUDIES AND FUEL CYCLE ANALYSIS. Haefele, W.; Gmelin, W.; Gupta, D.; Larisse, J.; Winter, H. (Kernforschungszentrum, Karlsruhe, Ger.). pp 161-79 of The International Conference on Constructive Uses of Atomic Energy. /Farmakes, Ruth (ed.). Hinsdale, Ill.; American Nuclear Society (1969).

From International Conference on the Constructive Uses of Atomic Energy, Washington, D. C. See CONF-681101.

Various phases of activities carried out at the Karlsruhe Research Center on safeguards systems are described. The safeguards requirements initiated at the Pu fabrication plant ALKEM at Karlsruhe are discussed. The method of assessing the relative importance of the chosen strategic points, preparation of material balance, and establishment of different types of statements that can be made by an inspection authority are described. The possibility of estimating the dynamic behavior of the process inventory for a given plant layout is analyzed. 19 references. (D.C.C.)

18693 SAFETY CONSIDERATIONS FOR FAST BREEDER REACTORS. McCarthy, Walter J. Jr. (Power Reactor De-

velopment Co., Detroit). pp 380-85 of The International Conference on Constructive Uses of Atomic Energy. /Farmakes, Ruth (ed.). Hinsdale, Ill.; American Nuclear Society (1969).
From International Conference on the Constructive Uses of Atomic Energy, Washington, D. C. See CONF-681101.

### Power Conversion Systems

18694 (EURFNR-655) THEDYBER: A PROGRAM FOR THE THERMODYNAMIC CALCULATION OF SYSTEMS FOR STEAM-COOLED NUCLEAR REACTORS, BASIC THEORY AND PROGRAM DESCRIPTION. Erbacher, F.; Harten, U. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Reaktorbauelemente). Translation of report KFK-824. 200p. Dep. CFSTI.
Work Performed under United States-Euratom Fast Reactor Exchange Program.
The program which is described is used for calculating the efficiency of a steam-cooled fast breeder reactor and provides the power, flow, pressure, temperature and enthalpy data required for the design of the cooling circuit. Four different circuit systems are calculated with the program, depending whether the lower turbines are mounted in parallel or in series with the power turbine and whether reheating is used or not. The influence of a number of different parameters is studied by means of a comprehensive input list. The program is also flexible, so that it can be modified and extended relatively simply. (auth)

## Research and Test Reactors

*Refer also to abstracts 16707, 17189, 17190, 17331, 17392, 18523, 18581, 18582, 18614, 18653, 18662, 18758, and 18759.*

18695 (BNWL-823) DESIGN SAFETY CRITERIA FOR THE FAST FLUX TEST FACILITY. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). 17 Jun 1968. Contract AT(45-1)-1830. 525p. Dep. CFSTI.
Revised information concerning design safety criteria for the FFTF is presented under the following headings: accident severity limits; electrical systems; structures; site facilities; service piping system; radioactive waste system; heating and ventillation system; plant fire protection system; containment system; reactor core; reactor vessel and shield component; control components; first core fuel assembly; reactor refueling system; nonirradiated fuel handling system; irradiated fuel handling system; radioactive maintenance system; reactor heat transport system; closed loop system; short-term irradiation facility; inert gas cell examination facility; Na receiving and processing system; inert gas receiving and processing system; instrumentation systems; and fuel failure monitoring system. (D.C.C.)

18696 (BNWL-1139) ANALYSIS OF FTR PHASE B CRITICAL EXPERIMENTS. PART 2. ZPR-III ASSEMBLIES 52a, b, c, d, e, AND f. Young, W. R.; Bennett, R. A. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Feb 1970. Contract AT(45-1)-1830. 50p. Dep. CFSTI.
Critical experiments in support of the design of the Fast Flux Test Reactor have been carried out in ZPR-III Assemblies 48, 48A, 51, and 52a, b, c, d, e, and f. The results and analysis of the experiments performed in Assemblies 52a, b, c, d, e, and f are presented. (auth)

18697 (BNWL-1304) REACTOR PHYSICS QUARTERLY REPORT, OCTOBER-DECEMBER 1969. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Feb 1970. Contract AT(45-1)-1830. 131p. Dep. CFSTI.

AMERICIUM ISOTOPES Am-241—criticality calculations for water moderated high concentration assembly
CRITICAL ASSEMBLIES—criticality of water moderated plutonium oxide ($PuO_2$)-uranium oxide ($UO_2$) fueled CAF, measurement of
—use of ZPR-3, for reactivity worth measurements of FTR control elements
CRITICALITY STUDIES—measurement of water moderated plutonium oxide ($PuO_2$)-uranium oxide ($UO_2$) fueled CAF
—calculation of transuranium actinides
CURIUM ISOTOPES Cm-244—criticality calculations for water moderated high concentration assembly
FAST TEST REACTOR—core components for, effects of fast neutrons on displacement and swelling of
—control elements for, use of ZPR-3 for reactivity worth measurements of
HIGH-TEMPERATURE LATTICE TEST REACTOR—control system for, description of on-line digital computer
—control rods of, physics measurements for
NEPTUNIUM ISOTOPES Np-237—criticality calculations for water moderated high concentration assembly
NEUTRONS, FAST—spectra in Fast Neutron Cavity of Physical Constants Testing Reactor
—effects on displacement and swelling of FTR core components
NEUTRONS, INTERMEDIATE—spectra in Fast Neutron Cavity of Physical Constants Testing Reactor
PHYSICAL CONSTANTS TESTING REACTOR—physics measurements for plutonium oxide ($PuO_2$)-uranium oxide ($UO_2$) fueled
—design parameters of Fast Neutron Cavity
—neutron spectra in Fast Neutron Cavity
PLUTONIUM ISOTOPES Pu-238—criticality calculations for water moderated high concentration assembly
PLUTONIUM ISOTOPES Pu-239—criticality calculations for water moderated high concentration assembly
PLUTONIUM ISOTOPES Pu-240—criticality calculations for water moderated high concentration assembly
PLUTONIUM RECYCLE TEST REACTOR—physics calculations for plutonium oxide ($PuO_2$)-uranium oxide ($UO_2$) fueled 19 rod cluster, comparison of one and two dimension
REACTIVITY—worth measurements of FTR control elements, use of ZPR-3 for
REACTOR CONTROL ELEMENTS—physics measurements for HTLTR rod type
—reactivity worth of FTR, use of ZPR-3 for measurement of
REACTOR CONTROL SYSTEMS—computer, description of HTLTR on-line digital
REACTORS—physics studies on, digital computer programs for
REACTORS, FAST—physics studies on, summary of October to December 1969
REACTORS, THERMAL—physics studies on, summary of October to December 1969 (D.L.C.)

18698 (CEA-CONF-1454) PERFORMANCE OF NEUTRON DETECTORS DEVELOPED IN FRANCE FOR REACTOR CONTROL. Bacconnet, E.; Comte, R.; Duchene, J. (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Oct 1969. 29p. (In French). (CONF-691115-1). Dep. CFSTI (U. S. Sales Only).
From Symposium on the Performance of Nuclear Power Reactor Components, Prague, Czechoslovakia.
The neutronics instrumentation which is used in the control systems at Saclay and Cadarache reactor centers is discussed. The characteristics of the fission chambers, $BF_3$ counters, and associated electronics are outlined. Calibration and dead-time measurements are described; data are presented in tabular and graphic form. Time-, high-temperature-, and high-flux-response of the fission chambers and $BF_3$ detectors are discussed; results of measurements are given. The development of high temperature and high flux cables for the in-core instrumentation is discussed. (M.L.S.)

18699 (CONF-690910) NATIONAL SYMPOSIUM ON DEVELOPMENTS IN IRRADIATION TESTING TECHNOLOGY, SEPTEMBER 9-11, 1969, NASA LEWIS RESEARCH CENTER, SANDUSKY, OHIO. (National Aeronautics and Space Administration, Cleveland, Ohio. Lewis Research Center). 794p. Dep. CFSTI.
Topics related to radiation testing technology are discussed under the following main headings: capsule design and experimental techniques for fast reactor irradiations; environmental control; environmental determination; post-irradiation examination; techniques and applications; and capsule design, fabrication, and operating experience. Separate abstracts are presented for 44 of the 51 papers included. Seven of the papers have been previously abstracted and can be located in the NSA Report Number Index under: DUN-SA-107; DUN-SA-108; GA-9653; ORNL-TM-2716; UCRL-71703; UCRL-71704; and UCRL-71899. (D.C.C.)

*For abstracts of individual papers see: 16734-16741, 16805, 16806, 16832, 16914, 17325-17329, 17388-17391, 18645-18647, 18700-18713, 18758, 18759, and 18785-18788.*

18700 (CONF-690910-, pp 38-51) CAPSULES AND SODIUM LOOPS USED IN ARGONNE NATIONAL LABORATORY REACTOR SAFETY EXPERIMENTS IN THE TREAT REACTOR. Robinson, L. E.; Ivins, R.; Dickerman, C. E. (Argonne National Lab., Ill.).
The development of radiation target cans for use in the TREAT facility is reviewed. Experimental facilities and equipment are described. Descriptions of the Mark 1 and Mark 2 in-pile Na loops for the TREAT facility are included. 15 references. (D.C.C.)

18701 (CONF-690910-, pp 52-8) USE OF THE THERMAL TREAT REACTOR FOR FAST REACTOR SAFETY STUDIES.

Dickerman, C. E.; Ivins, R. O.; Rothman, A. B.; Boland, J. F. (Argonne National Lab., Ill.).

Design parameters of the TREAT facility are discussed. Experimental facilities are described. 20 references. (D.C.C.)

18702 (CONF-690910–, pp 153-6) REACTOR FACILITY FOR NEUTRON IRRADIATIONS AT TEMPERATURES RANGING FROM -193 TO 725°C. Struss, R. G.; Chen, C. W. (Iowa State Univ. of Science and Technology, Ames. Inst. for Atomic Research. Ames Lab., Iowa).

An experimental facility in the Ames Research Reactor is described which has a variable temperature in a fast neutron flux environment. The combination of using a flux converter in the reactor in conjunction with the temperature control in a cryostat is discussed. 3 references. (D.C.C.)

18703 (CONF-690910–, pp 197-209) COMPACT 30 KW CIRCULATING HELIUM CAPSULE FOR FUEL ELEMENT TESTS IN NASA PLUM BROOK REACTOR. McDonald, G. E.; Putre, H. A.; Swanson, M. C.; Finnegan, P. M.; Homyak, L. (National Aeronautics and Space Administration, Cleveland, Ohio. Lewis Research Center).

A capsule has been endurance tested out of pile and two capsules have been tested in the Plum Brook Reactor. The capsule operates at pressures to 2500 psi, motor speed to 3000 rpm, flow rates to 0.09 lb He/sec, capsule wall temperatures to 1000°F, specimen powers to 30 kW with 180°F cooling water. Demonstrated out-of-pile life is at least 3000 hours. Fuel specimen surface heat fluxes of 2 kW/in.$^2$ have been obtained in pile. The capsule is 18 feet long with 4.3 inch maximum OD and 2.875 OD in the test section. It is composed of a variable speed electric motor driven vane pump, concentric tube heat exchanger, and a fuel element test section. The capsule is made of modified commercially available parts. Provisions are made for 15 thermocouples. Pressure leads used for filling are also used to measure gas flow rate and monitor coolant gas for fission product leaks. A loss of coolant accident can be contained without reactor scram for specimen powers of 30 kW or less. Capsules are relatively inexpensive and can be discarded when the test is completed. (auth)

18704 (CONF-690910–, pp 210-20) EXPERIMENT DESIGN STUDIES FOR FUEL PIN DEVELOPMENT. Stein, Ralph; Homyak, Len; DeFayette, Robert (National Aeronautics and Space Administration, Cleveland, Ohio. Lewis Research Center).

A mockup of a UN fuel pin proposed for a space power reactor was designed and tested in the NASA-ZPR-1 Reactor. The method used to simulate the UN and to measure the power gradients and power densities is described. Results are presented showing the effect of a Hf shield in reducing the power gradients. (auth)

18705 (CONF-690910–, pp 251-66) IN-PILE GAMMA DOSIMETRY MEASUREMENTS WITH OXALIC ACID. Power, J. L. (National Aeronautics and Space Administration, Cleveland, Ohio. Lewis Research Center).

The $\gamma$ dose rates in the NASA Research Reactor are measured. Concentrated oxalic acid ($H_2Ox$) was chosen as the only chemical $\gamma$ dosimeter both compatible with the lead-type capsule system to be used and capable of measuring the high $\gamma$ dose rates present. Experimental procedures and results are presented. 6 references. (D.C.C.)

18706 (CONF-690910–, pp 296-306) MEASUREMENT OF INTERNAL PRESSURE BUILDUP IN FULL-SIZED FUEL RODS DURING IRRADIATION. Burley, T. B. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.).

Full-sized $PuO_2$-$UO_2$ fuel rods were instrumented to monitor internal gas pressures and plenum gas temperature during irradiation in the PRTR. Performances of the instrumented fuel rods are described. (auth)

18707 (CONF-690910–, pp 330-49) GROOVED MELT WIRES FOR TEMPERATURE MEASUREMENT OF REACTOR FUEL. Salgado, P. G.; Thamer, B. J.; Rudman, R. L. ([Los Alamos Scientific Lab., N. Mex.]).

As a means for measuring temperatures in UHTREX, certain fuel elements have been examined after test to see which of an implanted array of melt wires have melted. Grooved melt wires have been developed covering the temperature range of 275° to 3000°F. Melting can be determined easily and with good precision by radiographing the exposed fuel element or by removing the melt wires for a visual examination. (auth)

18708 (CONF-690910–, pp 378-400) OBSERVATION OF FUEL FAILURE BEHAVIOR DURING IN-PILE MELTDOWN TESTS USING HIGH-SPEED PHOTOGRAPHY AND A TRANSPARENT AUTOCLAVE. Barghusen, John J.; Harrison, Lawrence J.; Ivins, Richard O.; Robinson, Lewis E. (Argonne National Lab., Ill.).

A study involving excursion accidents in water-cooled thermal reactors is described. Single fuel rod specimens in a transparent autoclave are subjected to destructive nuclear transients while being observed and photographed. The failure threshold energy and mechanism of failure of Zircaloy-clad $UO_2$ fuel rods are analyzed. The TREAT facility was used for the testing program. 6 references. (D.C.C.)

18709 (CONF-690910–, pp 652-68) RETRACTABLE-REPLACEABLE THERMOCOUPLE FOR IN-PILE EXPERIMENTS. Heckelman, James D. (National Aeronautics and Space Administration, Cleveland, Ohio. Lewis Research Center).

A design which allows the replacement of an in-core high temperature thermocouple located in an experimental capsule of a reactor has been developed, tested, and qualified for in-core use. The design is acceptable for fueled capsules, which require double containment. The thermocouple is remotely retractable so that it can be stored in a low temperature, low neutron flux zone to prolong its life. (auth)

18710 (CONF-690910–, pp 669-78) FLOWING SODIUM CAPSULES IN THE GENERAL ELECTRIC TEST REACTOR. Tunnell, G. W.; Brown, D. L. (General Electric Co., Pleasanton, Calif.).

The development of a facility to conduct fuel tests in a flowing liquid metal environment in a thermal test reactor is discussed. This facility allows fuel tests to be conducted at coolant velocities, powers, and temperatures which represent operating conditions for LMFBR and space power reactors. The capsule consists of concentric annuli in a closed loop coolant flow path. The flexibility of the design allows particular experiments to meet specifications within wide ranges of power and temperature levels, coolant flow rate, and neutron flux and spectrum. 3 references. (auth)

18711 (CONF-690910–, pp 679-89) FAST REACTOR FUEL TESTING IN FORCED CONVECTION CAPSULES. Novak, P. E.; Pfefferlen, H. C.; Murata, R. E.; Tunnell, G. W. (General Electric Co., Sunnyvale, Calif. Breeder Reactor Development Operation).

The mechanical and thermal design parameters of the forced convection capsule are presented. Operation of an initial test using a forced convection capsule is described. The capsule permits the use of extensive instrumentation and a range of temperatures and flow-rates. (D.C.C.)

18712 (CONF-690910–, pp 733-41) FAST REACTOR SODIUM-BONDED FUEL ROD EVALUATION IN A THERMAL REACTOR. Montgomery, Michael H.; Grando, Carl J.; Strasser, Alfred A. (United Nuclear Corp., Elmsford, N. Y.).

The radiation testing of Na-bonded, PuC–UC fuel rods at high burnup is described. An instrumented Na-bonded, PuC–UC fuel capsule has been designed to operate at a minimum linear power of 820 W/cm to an exposure of $35 \times 10^{20}$ fiss/cm$^3$. (auth)

18713 (CONF-690910–, pp 775-83) DESIGN AND IN-PILE OPERATION OF INSTRUMENTED HYDRAULIC CAPSULES. Rohal, Robert G. (National Aeronautics and Space Administration, Cleveland, Ohio. Lewis Research Center).

An in-pile hydraulic capsule facility was designed, built, and tested which permits temperature readings within the capsule to be obtained without the use of leads coming directly from the capsule. This is accomplished by using pins which penetrate the capsule walls through an insulating ceramic seal. The portion of the pin inside the capsule is connected to one leg of a thermocouple. The exterior portion has a spring attached which contacts a commutator permanently installed in the in-pile facility. The other leg of the thermocouple is grounded to the facility. The thermocouple signal is transmitted from the capsule through the pin to the commutator by the spring, and from the commutator to recorders by permanent leads. (auth)

18714 (DOCKET-50184-19) NATIONAL BUREAU OF STANDARDS REACTOR. Operations Report No. 7, October–December 1969. (National Bureau of Standards, Washington, D. C.). 19 Feb 1970. 11p. Dep. CFSTI.

18715 (IN-1335, pp 83-90) ENGINEERING EXPERIMENTS. (Idaho Nuclear Corp., Idaho Falls).

Limiting heat transfer capability in natural convection and in emergency and operational flow regimes has been determined in the ATR startup program by means of specially designed and instrumented experimental fuel elements. Hydraulic tests on ATR fuel elements to determine the cause of observed flow reduction in Channel 20 have resulted in modifications to the venting arrangement in the fuel element side plates. (auth)

**18716** (IN-1335, pp 91-106) CRITICAL FACILITIES. (Idaho Nuclear Corp., Idaho Falls).

A Coupled Fast Reactivity Measurement Facility has been installed in ARMF-II for measurement of fast neutron integral cross sections. Fission rate studies in ATRC have shown good correlation between experiment fluxes and lobe power. A new set of weighting factors has been obtained in ATRC to aid in calculations of power generated in fuel elements. Significant progress is reported toward flux stabilization in ETR. (8 references) (auth)

**18717** (IS-2100, Sect. R) REACTOR DIVISION. Hansen, R. S.; Voight, A. F.; McCorkle, W. H.; (and others) (Ames Lab., Iowa). 51p.

Progress is reported on research and development projects for the period July 1968 through June 1969. The majority of the projects summarized concern the operation and utilization of the Argonne Low-Power Research Reactor (ALRR). Separate sections discuss: (1) fuel burnup, refueling operations, and general use of the ALRR; (2) modifications to the ALRR; (3) support of ALRR experiments; and (4) general development projects. (H.D.R.)

**18718** (JAPFNR-2) TEST MANUFACTURING OF FUEL ASSEMBLIES FOR EXPERIMENTAL FAST BREEDER REACTOR (II) (FCRE-II). (Power Reactor and Nuclear Fuel Development Corp., Tokai (Japan)). Translation of Japanese report. 259p. Dep. CFSTI.

Studies and evaluations on fuel pins subassembly for JEFR (Japan Experimental Fast Breeder Reactor) are described. Grid design that has the most important function in the fuel subassembly is studied and assessed for its three types. A detail design of a small test fuel subassembly for the irradiation in the Rapsodie fast reactor is being performed based upon the experiences obtained from these studies. A series of design, fabrication and assessment studies is described for a modified A type grids assembly (rhombic compartment, FCRE-II). All the inspection and fabrication procedures except the preparation of natural $UO_2$ core material as the stand-in of mixed oxide were applied similarly to the future fabrication of plutonium bearing fuel. 5 references. (auth)

**18719** (NP-18138) LOCAL PILE OSCILLATOR AS A DEVICE FOR MEASURING TEMPERATURE DEPENDENCE IN EPITHERMAL-NEUTRON ABSORPTION. Dekker, Arij Leendert (Technische Hogeschool, Delft (Netherlands)). 1969. 130p. Dep. CFSTI (U. S. Sales Only).

Thesis.

Use of the pile oscillator in research reactors for measuring temperature dependence of epithermal neutron absorption is discussed. Detailed descriptions of oscillator components are given; data collection and reduction methods are described. Methods for calibration of the oscillator are discussed. Analytical techniques for computing resonance integrals and Doppler coefficients are described. Computed and measured values are compared. (70 references) (M.L.S.)

**18720** (ORNL-TM-2837) ANNUNCIATOR SCAN PROGRAM FOR THE HFIR DIGITAL CONTROL AND DATA ACQUISITION SYSTEM. Bullock, J. B.; Danforth, H. P. (Oak Ridge National Lab., Tenn.). 9 Feb 1970. Contract W-7405-eng-26. 23p. Dep. CFSTI.

The on-line digital computer at the HFIR is programmed to scan each of the safety related annunciators every 200 msec and list the name and time of occurrence of each alarm. The program logic is described and detailed program listings are included. (auth)

**18721** (ORNL-TM-2911) HIGH FLUX ISOTOPE REACTOR QUARTERLY REPORT, OCTOBER-DECEMBER 1969. McCord, R. V.; Corbett, B. L. (Oak Ridge National Lab., Tenn.). 5 Mar 1970. Contract W-7405-eng-26. 18p. Dep. CFSTI.

An unusual number of shutdowns was experienced at the HFIR during the report period. Ten scheduled and six unscheduled shutdowns were recorded. Despite the downtime accumulated during the last two quarters of the year, the operating time for 1969 was 90.7%. Two of the unscheduled shutdowns resulted from mechanical failures. One long shutdown was caused by a failure in the mechanical coupling of the only operable main pressurizer pump. Another shutdown and fuel changeout was required when the primary coolant strainer basket failed. (auth)

**18722** (RISO-M-982) MTR-TYPE FUEL ELEMENT MODEL EXPERIMENTS AT REACTOR DR 3. II. SUMMARY OF EXPERIMENTAL RESULTS. Rasmussen, Ingv. (ed.) (Danish Atomic Energy Commission, Risoe. Research Establishment). Oct 1969. 72p. Dep. CFSTI (U. S. Sales Only).

Investigations on the performance of MTR-type fuel element subchannels operating under high heat load conditions were carried out during 1966-69 in the X-57 loop facility of the reactor DR 3 at Riso. The fuel plate and channel performance were studied under steady-state and transient conditions within the single-phase forced convection and the subcooled boiling flow regimes, including approaches to burn-out. Fuel failure and fission product release due to insufficient cooling were investigated under controlled circumstances. The studies of the operational behavior of fuel plates were supported by comprehensive postirradiation examinations. Miniature in-core instrumentation was developed to achieve the various objectives of the research work. A summary of the main experimental results is given. (auth)

**18723** (UARAEE-8) CALCULATION OF NEUTRON ENERGY SPECTRUM IN THE UA-RR-1 REACTOR CORE. Yousef, M. Y. A.; Lukyanov, A. A. (Atomic Energy Establishment, Cairo (Egypt). Theoretical Physics Dept.). May 1965. 20p. Dep. CFSTI (U. S. Sales Only).

The calculation of the slowing-down neutron spectrum for the UA-RR-1 reactor is based on the approximate method previously developed. The Wigner-Wilkins method is used to obtain the spectrum of thermal neutrons. The results of the thermal-neutron spectrum calculation correlate satisfactorily with experimental data. (auth)

**18724** (UNC-5233) FAST REACTOR MIXED-CARBIDE FUEL ELEMENT DEVELOPMENT PROGRAM. Fifth Quarterly Progress Report, July-September 1968. (United Nuclear Corp., Elmsford, N. Y. Research and Engineering Center). 12 Dec 1968. Contract AT(30-1)-3415. 44p. Dep. CFSTI.

EXPERIMENTAL BREEDER REACTOR-II—fuel rods for, fabrication and radiation testing of plutonium carbide (PuC)-uranium carbide (UC)
LIQUID METAL FAST BREEDER REACTOR—fuel elements for, development of mixed carbide
NEUTRONS, FAST—effects on plutonium carbide (PuC)-uranium carbide (UC) rod type fuel elements, in EBR-2
PLUTONIUM CARBIDES—PuC-UC, fabrication of fuel rods of, for EBR-2
—PuC-UC, radiation testing of fuel rods of, for EBR-2
—PuC-UC, fabrication of pellets of, quality control for pilot plant process
PLUTONIUM OXIDES $PuO_2$—$PuO_2$-$UO_2$, fabrication of pellets of, quality control for
REACTOR FUEL ELEMENTS—development of mixed carbide, for LMFBR
—fabrication of plutonium carbide (PuC)-uranium carbide (UC) rods for EBR-2
—radiation effects on EBR-2 plutonium carbide (PuC)-uranium carbide (UC) rod type, measurement of fast neutron
URANIUM CARBIDES—PuC-UC, fabrication of fuel rods of, for EBR-2
—PuC-UC, radiation testing of fuel rods of, for EBR-2
—PuC-UC, fabrication of pellets of, quality control for pilot plant processes
URANIUM OXIDES $UO_2$—$PuO_2$-$UO_2$, fabrication of pellets of, quality control for (D.C.C.)

**18725** (UNC-5238) FAST REACTOR MIXED-CARBIDE FUEL ELEMENT DEVELOPMENT PROGRAM. Quarterly Progress Report No. 6, October-December 1968. (United Nuclear Corp., Elmsford, N. Y. Research and Engineering Center). 1 Apr 1969. Contract AT(30-1)-3415. 39p. Dep. CFSTI.

EXPERIMENTAL BREEDER REACTOR-II—fuel rods for, fabrication and radiation testing of plutonium carbide (PuC)-uranium carbide (UC)
LIQUID METAL FAST BREEDER REACTOR—fuel elements for, development of mixed carbide
NEUTRONS, FAST—effects on plutonium carbide (PuC)-uranium carbide (UC) rod type fuel elements
PLUTONIUM CARBIDES—PuC-UC, fabrication of fuel rods of, for EBR-2
—PuC-UC, radiation testing of fuel rods of, for EBR-2
—PuC-UC, fabrication of pellets of, quality control for pilot plant process
PLUTONIUM OXIDES $PuO_2$—$PuO_2$-$UO_2$, fabrication of pellets of, quality control for
QUALITY CONTROL—methods for fabrication of plutonium carbide (PuC)-uranium carbide (UC) and plutonium oxide ($PuO_2$)-uranium oxide ($UO_2$) pellets
REACTOR FUEL ELEMENTS—development of mixed carbide, for LMFBR
—radiation effects on plutonium carbide (PuC)-uranium carbide (UC) rod type, measurement of fast neutron
—fabrication of plutonium carbide (PuC)-uranium carbide (UC) rods for EBR-2

URANIUM CARBIDES— PuC–UC, fabrication of fuel rods of, for EBR-2
— PuC–UC, radiation testing of fuel rods of, for EBR-2
— PuC–UC, fabrication of pellets of, quality control for pilot plant process
URANIUM OXIDES $UO_2$— $PuO_2$–$UO_2$, fabrication of pellets of, quality control for (D.C.C.)

18726 (UNC-5248) FAST REACTOR MIXED-CARBIDE FUEL ELEMENT DEVELOPMENT PROGRAM. Quarterly Progress Report No. 8, April-June 1969. (United Nuclear Corp., Elmsford, N. Y. Research and Engineering Center). 16 Sep 1969. Contract AT(30-1)-3415. 31p. Dep. CFSTI.

EXPERIMENTAL BREEDER REACTOR-II— fuel rods for, fabrication and radiation testing of plutonium carbide (PuC)— uranium carbide (UC)
LIQUID METAL FAST BREEDER REACTOR— fuel elements for, development of mixed carbide
NEUTRONS, FAST— effects on plutonium carbide (PuC)–uranium carbide (UC) rod type fuel elements
PLUTONIUM CARBIDES— PuC–UC, fabrication of fuel rods of, for EBR-2
— PuC–UC, radiation testing of fuel rods of, for EBR-2
PLUTONIUM OXIDES $PuO_2$— $PuO_2$–$UO_2$, fabrication of pellets of, quality control for
QUALITY CONTROL— methods for fabrication of plutonium oxide ($PuO_2$)–uranium oxide ($UO_2$) pellets
REACTOR FUEL ELEMENTS— development of mixed carbide, for LMFBR
— fabrication of plutonium carbide (PuC)–uranium carbide (UC) rods for EBR-2
— radiation effects on plutonium carbide (PuC)–uranium carbide (UC) rod type, measurement of fast neutron
URANIUM CARBIDES— PuC–UC, fabrication of fuel rods of, for EBR-2
— PuC–UC, radiation testing of fuel rods of, for EBR-2
URANIUM OXIDES $UO_2$— $PuO_2$–$UO_2$, fabrication of pellets of, quality control for (D.C.C.)

18727 AUTOMATION OF COMPLEX EXPERIMENTAL DEVICES IN A NUCLEAR REACTOR. Guerin, M.; Grevaz, M. (CEN, Grenoble, France). Bull. Inform. Sci. Tech. (Paris); No. 143, 3-8(Dec 1969). (In French).

The operation of experimental devices during irradiation in the core of the nuclear reactor involves the processing of a large number of experimental data. A numerical computer has been installed at the Pile Service of the C.E.N. Grenoble to perform the various operations necessary in real time. The functions of the unit described are: the inspection and recording of data obtained from experiments; identification of the characteristics of the apparatus under supervision; and automatic running of the devices. Finally, advantage is taken of the dead times of the central unit of the computer to analyze the results of flux measurements by activation as they leave a counting room. (auth)

18728 CRITICAL MASS IRREGULARITY OF STEEL-MODERATED ENRICHED URANIUM METAL ASSEMBLIES WITH COMPOSITE STEEL-OIL REFLECTORS. Coonfield, Donald C.; Tuck, Grover; Clark, Harold E.; Ernst, Bruce B. (Dow Chemical Co., Golden, Colo). Nucl. Sci. Eng.; 39: 320-8(Mar 1970).

Critical masses have been determined by experiment and by calculation for enriched-uranium-metal spherical shells moderated internally with a sphere of mild steel of radius 8.01 cm. The shells were reflected with various thicknesses of mild steel followed by an effectively infinite amount of oil. The points representing critical mass as a function of the thickness of the steel reflector are not related by a smooth curve. The irregularity appears to be most severe for a 3-cm-thick steel reflector and is due to the resonance in the neutron elastic-scattering cross section of iron. 7 references. (auth)

18729 LOW FLUX MEASUREMENTS OF $^{239}Pu$ AND $^{235}U$ CAPTURE-TO-FISSION RATIOS IN A FAST REACTOR SPECTRUM. Bretscher, M. M.; Redman, W. C. (Argonne National Lab., Ill.). Nucl. Sci. Eng.; 39: 368-78(Mar 1970).

The effective capture-to-fission ratio $\bar{\alpha}$ has been measured for $^{239}Pu$ and $^{235}U$ in a low flux fast-reactor spectrum by the reactivity-reaction-rate technique. A $^{252}Cf$ source and a $^{6}Li$ absorber were used to measure the relative importance of fission and absorbed neutrons, respectively. The measurements were made in Assembly 24 of ZPR-9 which was designed to produce a neutron spectrum that emphasized fission and capture events in the 0.1 to 25 keV range. For $^{239}Pu$ and $^{235}U$ the measured $\bar{\alpha}$ values, corrected to infinite sample dilution, were $0.516 \pm 0.040$ and $0.337 \pm 0.029$, respectively. Corresponding integral alpha values calculated from ENDF/B were 0.352 and 0.346. The experimental value for $\bar{\alpha}^{239}$ is in reasonable agreement with calculations based on recent differential data obtained by both the Oak Ridge–Rensselaer and the United Kingdom groups. These calculations yielded $^{239}Pu$ alpha values of 0.466 (ORNL-RPI) and 0.471 (UK). 32 references. (auth)

18730 CRITICAL ASSEMBLY FOR THE SHIP PROPULSION PROGRAM. Albergamo, V.; Santandrea, E.; Villani, A. (CNEN–CSN, Casaccia, Italy). Com. Naz. Energ. Nucl., Notiz.; 15: No. 12, 35-51(Dec 1969). (In Italian).

At the Casaccia Nuclear Research Center the reactor which had been in operation since 1963 under the name of Rospo has recently been adapted for use in the Ship Propulsion Program. To this end several changes have been introduced, making the reactor suitable for testing PWR-type cores. (auth)

18731 FUELS AND MATERIALS IRRADIATION PROGRAM IN SUPPORT OF FFTF. Roake, W. E.; Tobin, J. C. (Battelle-Northwest, Richland, Wash.). Nucl. News; 13: No. 3, 58-61(Mar 1970).

The Fast Flux Test Facility is described, and irradiation programs on Fast Test Reactor fuels and materials are reviewed. Some of the irradiation testing conducted in both thermal and fast reactor facilities is summarized. (H.D.R.)

18732 EFFECT OF COOLANT CHANNEL DIAMETER ON HOMOGENEOUS AND HETEROGENEOUS METHODS OF REACTOR ANALYSIS IN REFLECTED SUBCRITICAL ASSEMBLY. Haroon, M. R. (Georgia Inst. of Tech., Atlanta). J. Phys., D (London); 3: 422-30(Mar 1970).

The systematic variation of neutron flux distribution and buckling measurements as a function of fuel loading in a subcritical assembly (graphite, natural uranium) for two different coolant channel diameters was investigated. The void ratio (volume of voids/lattice volume) in the two cases was 19% and 24%. The experimental results have been compared with theoretical predictions based on diffusion theory. For full assembly cases the results are in good agreement with the predictions of Syrett's (1962) model for graphite moderated reactors. The correlation of 100 partially filled assembly cases was carried out in three ways: (1) Syrett method lattice parameters with reflector savings calculated from one- and two-group theory for an infinite-slab system. (2) Numerical solution of the two-group, two-region diffusion equations. (3) Two-group heterogeneous (source sink) theory for finite systems. The results show that method (1) breaks down for all cases except those with the full assembly, method (2) breaks down in nearly all cases and method (3) holds well down to 36 fuel channels. The breakdown in method (1) and (2) is most probably due to inaccurate streaming corrections to reactor systems of smaller size. In method (2), excessive computer time is an additional complicating factor. If the experiments are analyzed by heterogeneous methods it is possible to obtain accurate reactor parameters with a partially loaded exponential assembly in cases where only a limited amount of fuel is available. (auth)(UK)

18733 RADIATSIONNYE KONTURY–ISTOCHNIKI GAMMA-IZLUCHENIYA. (Radiation Loops–Gamma Radiation Sources). Dindun, A. S.; Gavar, V. V.; Tomson, E. Ya. Riga; Izdatel'stvo Zinatne (1969). 204p.

A brief analysis is given of the theoretical and technological problems in the operation of radiation loops (in-pile loops). A brief history of the development of radiation loops and the comparison of radiation loops with other sources of radiation are discussed. Construction and operation problems are described. Shielding requirements for in-pile loops are reviewed. Safety regulations for in-pile loop operation are presented. (191 references) (R.V.J.)

18734 IRRADIATION EXPERIMENTS IN ORNL. Miyao, Jiro (Japan Atomic Energy Research Inst., Tokyo). Nippon Genshiryoku Gakkaishi; 12: 74-9(Feb 1970). (In Japanese).

Irradiation experiments at ORNL are described. Capsules used at ORNL for metal specimens, for in-pile creep tests and for fission product release experiments are outlined, and a description is given of hydraulic irradiation facilities at the Oak Ridge Research Reactor. (9 references) (auth)

18735 INVESTIGATION OF LIGHT WATER MODERATED LATTICE BY DIFFERENTIAL REACTIVITY METHOD. Bouzyk, J.; Kubowski, J.; Latek, S. (Inst. of Nuclear Research, Swierk, Poland). Kernenergie; 12: 376-9(Dec 1969).

The differential reactivity method was applied to investigate a light water moderated critical assembly fueled with $UO_2$ (enriched to 36% w/o in $^{235}U$). The age, multiplication factor, reflector savings, material buckling and reactivity of control rods have been obtained. The importance of the reflector factor has

been considered and experimental technique used for its determination is described. (auth)

18736 SOME EXPERIMENTAL NEUTRON PHYSICAL PARAMETERS OF CO-1 ASSEMBLY. Konstantinov, L. V.; Nikolaev, V. A.; Efanov, A. I.; Ustinov, A. A. At. Energ. (USSR); 28: 53-5(Jan 1970). (In Russian).

A description is given of the neutron source CO-1 subcritical system used for activation analyses. The activation zone of the system was assembled with uranium polyethylene disks. The activation zone is 200 mm in diameter and 230 mm high. Uranium dioxide fuel, enriched up to 36% with $^{235}U$, is homogeneously dispersed in the polyethylene. Tabulated data are given on measured thermal fluxes of $10^7$ neutrons/cm$^2$-sec in the CO-1 installation. Data obtained suggested the following parameters for the installation: $0.5 \times 10^{-2}$ subcriticality; $^{238}Pu-Be$ ($T_{\frac{1}{2}}$ = 89.6 years; Q = $2.3 \times 10^6$ neutrons/sec) source; 0.9 W; and the neutron flux in experimental channels equal to $1.3 \times 10^7$ neutrons/cm$^2$-sec. (R.V.J.)

18737 ESPERIENZE CIRO. SEMINARIO INTERNO CNEN 17-18 LUGLIO 1968. (CIRO Experiences. Internal Conference CNEN, July 17-18, 1968). Com. Naz. Energ. Nucl., Notiz.; 15: 27-74(Jan 1969). (In Italian). (RT/ING-(69)7; CONF-680728).

The overall CIRO program for development of an organic cooled irradiation loop for fuel element testing is described; costs of the program are outlined. Research and development objectives of the program are summarized. Design characteristics of the heat transfer systems and the fuel elements are discussed; principal parameters are tabulated. Basic neutronics characteristics of the Ispra-1 research reactor, in which the CIRO loop is located, are listed. Schematics show the arrangement of the in-pile section of the loop. Results of post-irradiation examination of the ceramic fuels are summarized. (M.L.S.)

18738 THE CRITICAL ASSEMBLY "RAKE". Endler, A. (Zentralinstitut fuer Kernforschung, Rossendorf, Ger.). Kernenergie; 12: 373-5(Dec 1969). (In German).

A brief presentation of the reasons leading to the construction, a description of the assembly in detail, and the physical limiting values of the critical assembly are included. (auth)

18739 A METHOD USING NUCLEAR EMULSIONS FOR MEASURING THE ANISOTROPY OF FAST NEUTRON FLUXES DUE TO ARRANGEMENT OF FAST CORE CELL. Nomoto, Shoji (Japan Atomic Energy Research Inst., Tokai); Yasuno, Takehiko; Nakamura, Hisashi. J. Nucl. Sci. Technol. (Tokyo); 7: 61-6(Feb 1970).

Measurements using nuclear emulsions were made on the neutron spectra and on the fine structure of neutron fluxes in the cell of the I-4 core of the fast critical assembly at the Japan Atomic Energy Research Institute. The I-4 core is a graphite-diluted fast core with 3:1 volume ratio of 20% enriched metallic uranium and graphite. The nuclear emulsions were irradiated in two typical patterns of arrangement of the cell (systems with graphite plates (a) bunched and (b) distributed among fuel plates). For the distributed graphite plate system a marked discrepancy was found between the direct measurements and calculations based on the Monte Carlo method. This is attributed to anisotropy in the incident neutron flux due to the parallel plate arrangement of the simulated materials. It is concluded that Reines' formula requires correction to account for such anisotropy, even when the emulsions are irradiated at the core center. A simple method for treating this anisotropy is proposed for use in fine structure analysis. The method utilizes, in part, the calculated results. (auth)

18740 INVESTIGATING THE TEMPERATURE CHANGES OF A BISMUTH FILTER NEAR THE ACTIVE ZONE OF IRT-1000. Vylov, Tsvetan; Gadzhokov, Vasil; Georgiev, Radoslav; Enchev, Dimitr; Misheva, Mariya; Tumbev, Georgi. Izv. Fiz. Inst. Aneb, Bulg. Akad. Nauk.; 19: 269-72(1969). (In Bulgarian).

The temperature changes in a Bi filter near the active zone of the IRT-1000 Reactor were investigated. It was determined that for small distances between the active zone and the filter the temparature of the latter reaches values near the melting point of Bi. The distance at which the bismuth filter can be placed without additional means of cooling and control is determined experimentally. This decision represents a compromise with respect to the intensity of the neutron beam. (auth)

18741 MEASUREMENT OF THE TEMPERATURE COEFFICIENT IN A NUCLEAR REACTOR FROM XENON POISONING. Rads, G.; Coello, E.; Ollarves, H. (Instituto Venezolano de Investigaciones Cientificas, Caracas). Acta Cient. Venez.; 19: 198-9(1968). (In Spanish).

If a reactor is scrammed after it has operated at an equilibrium concentration of Xe, the subsequent evolution of the total reactivity is affected by the increase of the concentration of Xe and by temperature changes which occur in the core. These effects can be separated, and the temperature coefficient of reactivity as a function of the temperature of the core can be determined. Typical curves for temperature and reactivity for the RV-1 reactor are illustrated and the correction of total evolution for the effect of Xe alone is applied. The equation for correction of the data for the effect of Xe is based upon a point reactor of a single group of neutrons, and ignores spatial distribution of neutron flux and spectral effects on the absorption section of Xe. Methods for correcting these simplifications are discussed. (BBB)

## Rocket and Space Reactors

*Refer also to abstracts 16737, 16806, and 16815.*

18742 (WANL-TME-1976) XE PRIME POWER CONTROL. Guyer, F. R. (Westinghouse Electric Corp., Pittsburgh, Pa. Astronuclear Lab.). 31 Oct 1969. Subcontract NP-1. 26p. Dep. CFSTI.

The more salient features of the power control used on the NERVA XE Prime are described. Emphasis is placed to show that the XE Prime power controller met all performance requirements without exception. The stability, bandwidth, and static accuracy were sufficient to permit all of the engine performance maneuvers desired of XE Prime. These included: (1) power holds, (2) power increase and decrease on short and long periods, and (3) power control during bootstrap. (auth)

18743 PLASMA-DYNAMIC STABILIZATION IN A COAXIAL-JET, GAS-CORE REACTOR. Cory, J. S. (Douglas Labs., Richland, Wash.). AIAA (Amer. Inst. Aeronaut. Astronaut.) J.; 7: 1614-16(Aug 1969).

The problem of suppressing turbulence at the fuel-propellant interface in a gaseous-core reactor is addressed. It is proposed that a magnetic nozzle be created to stabilize the coaxial-jet flow, and it is shown that a magnet power of 10 kW (1000 gauss) produces everywhere a generalized Richardson number greater than $\frac{1}{4}$ for a propulsion system producing 250,000-lb thrust at 1500-sec specific impulse. (D.L.C.)

18744 EXPLORATION OF THE SOLAR SYSTEM AND OF INTERSTELLAR SPACE. Ehricke, Krafft A. (North American Rockwell Corp., Downey, Calif.). Ann. N. Y. Acad. Sci.; 163: 493-553(4 Sep 1969).

Some main propulsion systems that have been proposed for manned interplanetary vehicles, including nuclear-powered ones, are reviewed. All rocket propulsion systems with specific impulses significantly in excess of those attainable by chemical propellants are based on the use of nuclear power sources in one form or another. The first step toward realization of the high performance of nuclear systems is the development of the solid-core reactor nuclear engine (NERVA). By the middle of the seventies, this propulsion system will be ready to occupy an important place in the hierarchy of advanced space propulsion systems. Attention is focused on still more advanced propulsion systems, whose specific impulse is in the kilosecond regime. Major representatives of this group are the gas-core reactor (GCR), nuclear electric (NE), nuclear pulse (NP), and controlled thermonuclear reactor (CTR) types. Their principal features are surveyed. Among the various GCR concepts, the light-bulb concept is particularly attractive. In the NE drive a stream of positive ions is generated, accelerated in an electrostatic field to high exhaust velocity and neutralized by electron injection into the ion jet following discharge. The NP drive uses small nuclear explosive charges (pulse units), which are stored in the vehicle. The pulse units are sequentially ejected and detonated at a given distance behind the vehicle. The CTR is a fusion system, based on the conversion of hydrogen to helium. It is suggested that the GCR should be given first priority, because it combines high value for cislunar transportation with a good initial heliocentric capability. The NP rates highest for an all-out heliocentric capability, and efforts should be made to solve the political problems inhibiting progress towards its development. The CTR rating is comparable to that of the NP, but the latter could be available sooner. NP and CTR are highly complementary and constitute the most attractive hybrid system for transportation encompassing the entire solar system and for precursory missions into ultra-planetary/interstellar space. (BBB)

18745 A SURVEY OF FUTURE SPACE PROPULSION SYSTEMS. Kuhrt, Wesley A. (United Aircraft Corp., Stradford, Conn.). Ann. N. Y. Acad. Sci.; 163: 453-65(4 Sep 1969).

Various space vehicle propulsion systems, including nuclear powered ones, are reviewed. It is suggested that for space propulsion beyond the late 1980's, the gaseous-core nuclear rocket

will provide for most of the late 20th-century space transportation. The basic gaseous-core rocket will be a technological advance of present work on solid-core nuclear rockets and high-pressure chemical rockets. The gaseous-core nuclear rocket design that is used for orbital transportation is designated the so-called nuclear light-bulb because of the use of a transparent wall to separate the gaseous nuclear fuel from the propellant, thus permitting perfect containment of nuclear fuel. The basic nuclear light-bulb engine, which is diagrammed, is composed of a number of parallel unit gaseous nuclear reactor cavities enclosed in a high-pressure shell. Hydrogen is pumped through the moderator-reflector and nozzle for regenerative cooling and heated radiatively in the unit cavities to very high temperatures. The hot hydrogen is expanded through the nozzle to provide the thrust in space. The high-power liquid hydrogen pump is powered by a turbo-hydrogen expander using the regeneratively heated hydrogen from the engine. The principle of operation of the nuclear rocket is explained and the single-unit cavity, which employs a vortex flow configuration to maintain a stable nuclear core within the reactor, is illustrated. (BBB)

18746 NUCLEAR PROPULSION APPLICATIONS. Plebuch, Richard K.; Martinez, John S. (TWR Systems Group, Redondo Beach, Calif.). Ann. N. Y. Acad. Sci.; 163: 358-79(4 Sep 1969).

The development and utilization of nuclear propulsion for aerospace applications are reviewed. Advancing technology and the increasing size of aircraft indicate that a nuclear airplane could have payloads competitive with conventional aircraft at ranges greater than 4000 miles. The thrust level selected for the NERVA nuclear rocket engine is reasonably optimum for performing the manned Mars mission via the all high-thrust mode; however, it may not be optimum for all the possible future missions with the nuclear rocket. The nuclear engines used for unmanned space probes or for the first stage in a nuclear/electric hybrid system may optimize at considerably lower thrust levels. The current effort should be aimed at the demonstration of a system in the 200 to 250 Klb range which would provide the propulsion capability to land men on the planet Mars within the next 20 yr. Mission studies indicate that if MW-class electric power plants can be developed having specific masses in the 15 to 20 Kg/KWe range, the nuclear rocket/electric propulsion hybrid system provides significant reduction in the weight required in earth orbit relative to the all high-thrust nuclear rocket to perform many energetic space missions. Long-lived, pulsed radioisotope thrusters operating with $NH_3$ propellant appear attractive for many near-term spacecraft auxiliary propulsion applications. Isotope-propelled upper stages using $H_2$ propellant offer potential for high-energy unmanned space missions. (BBB)

18747 NUCLEAR AIRCRAFT PROPULSION: TIME FOR A SECOND LOOK. Grey, Jerry (Greyrad Corp., Princeton, N. J.). Ann. N. Y. Acad. Sci.; 163: 310-19(4 Sep 1969).

It is suggested that the Aircraft Nuclear Propulsion (ANP) program, cancelled in 1961, should be reconsidered. Such reconsideration would be based on the acceptability of aircraft having higher gross weight than the rather arbitrary 500,000 lb limit set for the ANP vehicle. Removal of this simple limitation, together with elimination of the requirement for supersonic "dash" capability, now makes the nuclear-powered cargo airplane not only possible, but competitive, both economically and operationally, with conventional chemically fueled aircraft. The principal advantage offered by a nuclear engine, which needs no refueling, is unlimited range. Missions whose key requirement is payload-carrying over long distances are examined. The military usefulness of a fleet of such airplanes is commented on, and several critical requirements referred to. In addition to the operational need for aircraft that are economical, operationally practical, and able to utilize existing runways, it is necessary that safety be a prime factor. This calls for a unit shield around the reactor rather than the ANP's divided shield, so that not only the crew but all ground-handling personnel and passengers are protected. Also, the shield must be crashproof to avoid escape of radiation sources from the reactor in the event of an aircraft accident. Further, from a safety point of view as well as to minimize reactor power demand and, therefore, shield weight, it is advisable to utilize chemical fuel in the engines for takeoff and landing. Conversion of the C-5A aircraft to nuclear power and some aspects of engine design are also considered. (BBB)

18748 NUCLEAR-POWERED AIRPLANE. Rom, Frank E. Technol. Rev.; 72: 48-56(Dec 1969).

Some technical considerations are reviewed that indicate that it may be possible to make a large, long-range nuclear-powered aircraft which is economically competitive. Considerations of safety lead to some new concepts for reactor design and control. The basic concept of a nuclear power plant for aircraft use is described. The reactor's heat energy travels, in a good heat-transfer fluid such as high-pressure helium or liquid metal, to an exchanger, which heats the air flowing through a conventional turbofan engine. This heat exchanger is placed immediately in front of the normal combustor. The engine can then run on conventional fuel, or nuclear energy, or both. To be practical, safe, and publicly acceptable, a nuclear aircraft must meet certain requirements, which are outlined. The payload anticipated for a nuclear aircraft with a gross weight of 1.75 million lb is shown. The payload (cargo and chemical fuel) is plotted as a function of flight Mach number. Chemical fuel is provided for takeoff and landing and for 1 hr flying time at design flight conditions. The payload is ~500,000 lb for Mach numbers of 0.5 to 0.75. The fuel load is about 120,000 lb in this range, so that the cargo capacity is about 400,000 lb. This amounts to >20% of the gross weight. (BBB)

## Process Heat and Desalination Reactors

*Refer also to abstracts 18468 and 18509.*

18749 (NP-18147) NUCLEAR-POWERED AGRO-INDUSTRIAL COMPLEXES FOR AUSTRALIA. A Feasibility Study. Tolmie, D. B. (comp.) (Sydney Univ. (Australia). Dept. of Chemical Engineering). Oct 1969. 276p. Dep. CFSTI (U. S. Sales Only).

The feasibility of constructing industrial plants and irrigated agriculture, around a dual purpose reactor/desalination plant to take advantage of cheap (2 mills/KWH) power, and fresh water (20 to 30 cents/thousand gallons) is considered. Topics covered include Economics and Location, Financial and Political Aspects, Food Production in Desert Areas, Nuclear Power Technology, Desalination, Metal, Chemical and Fertilizer Production, generally in relation to the economics of large scale operation. (Australia)

18750 APPLICATION OF THE HTGR-CCGT SYSTEM IN DUAL-PURPOSE NUCLEAR-POWER PLANTS. Halzl, Jozsef; Szabo, Zoltan; Szuecs, Laszlo; Torma, Miklos. Energ. Atomtech.; 22: 521-9(Nov-Dec 1969). (In Hungarian).

The idea of using the HTGR-CCGT (Ackeret-Keller cycle) system for the simultaneous supply of heat and electricity is developed and applied to $Al_2O_3$-Al producing industrial complexes and to water desalination. General investigations concerning the suitability of the CCGT system for the combined production of heat and electricity are presented. On the basis of thermodynamic analysis-considering also the special features of the equipment involved-the optimum heat cycles dependent on the characteristics of the heat demand are presented. HTGR-CCGT dualpurpose power plants for two selected cases are described. Heat cycles are presented, which are suitable for the combined heat and electricity supply of $Al_2O_3$-Al producing industrial complexes. The application of the HTGR-CCGT system to water desalting is described. It is shown that the combination of the multi-flash and the humidification processes offers special advantages. The influence of the heat-exchanger costs on the over-all economy of the CCGT system is emphasized. To reduce the specific costs, the use of Hg as heat transfer medium is specially designed equipment is suggested. Solutions are presented concerning the design of the heat exchangers. Diagrams for the dimensioning of high-efficiency plate fins used in the very compact heat exchangers are presented. The diagrams take into account both the variation of the temperature field existing in the gas flow and the heat conduction of the fin in the direction of the flow. (auth)

18751 APPLICATION OF NUCLEAR REACTORS TO THE ALUMINA AND ALUMINUM INDUSTRY. Halzl, Jozsef; Sigmond, Gyoergy; Szabo, Zoltan; Torma, Miklos. Energ. Atomtech.; 22: 530-5(Nov-Dec 1969). (In Hungarian).

After a short description of the $Al_2O_3$ manufacturing processes and their energy demands, the results of economic calculations both for the back-pressure power plant supplying heat and electricity for an $Al_2O_3$ plant only, and for the power plant supplying both the $Al_2O_3$ plant and the Al smelter are presented. The economic calculations have been carried out in terms of the capacity of the alumina plant using: (a) amortization rate; (b) power credit; (c) cost of fossil fuel; and (d) temperature level of heat demand. Nuclear energy supply variants were based on the pressurized-water reactor, but for big $Al_2O_3$ plants and for the combined supply of the $Al_2O_3$ plant and the Al smelter, the application of advanced gas-cooled reactors was also investigated. (auth)

18752 DESALTING SEAWATER WITH NUCLEAR HEAT. Baer, Robert L. Power; 114: No. 3, 79-81(Mar 1970).

The Small Unified Reactor Facility with Systems for Isotopes, Desalting and Electricity (SURFSIDE) is described. The pressure-tube reactor and flashed vapor desalting plant will produce 2.5 MW(e), 1,000,000 gal/day of fresh water, and the equivalent of 400,000 curies of $^{60}Co$ annually. (H.D.R.)

# Marine and Portable Power Reactors

18753 TEPLOOBMENNYE APPARATY YADERNYKH ENERGETICHESKIKH USTANOVOK. (Heat Exchangers for Nuclear Power Installations). Andreev, P. A.; Gremilov, D. I.; Fedorovich, E. D. Leningrad; Izdatel'stvo Sudostroenie (1969). 353p.

Questions related to the design of heat exchangers for marine and power reactors are discussed. Hydrodynamic and thermal stability requirements are described. (138 references) (tr-auth)

18754 BIOLOGICHESKAYA ZASHCHITA TRANSPORTNYKH REAKTORNYKH USTANOVOK. (Biological Protection of Portable Reactor Installations). Broder, D. L.; Kozlovskii, S. A.; Kyzyurov, V. S.; Popkov, K. K.; Rubanov, S. M. Moscow; Atomizdat (1969). 420p.

The basic physical and design-calculational methods for reactor shielding are described. Neutron transport theory is developed for heterogeneous media. Calculational techniques are oriented toward the practical shielding calculations. Gamma yield and buildup are discussed; secondary $\gamma$ radiation sources and effects are analysed. Space-energy distributions are calculated for various media. (tr-auth)

18755 THE REACTOR INSTALLATION ON THE NUCLEAR ENERGY RESEARCH SHIP "OTTO HAHN." Kostrzewa, Siegfried (INTERATOM, Bensberg/Cologne, Ger.). Elektrotech. Z.; A90: 513-16(26 Sep 1969). (In German).

An illustrated description is given of the nuclear ship "Otto Hahn" which made its first test voyage on 11 October, 1968. It has made several long voyages, some under difficult sea conditions and under extreme climatic conditions, and they have been successful. These favorable results are mainly due to the integrated type of construction and operation of the reactor with automatic pressure maintenance. The integrated construction was achieved by the combination of the reactor core, steam generator, primary circulating pumps, and pressure maintenance into a compact unit in a pressurized container. The reactor installation has a thermal capacity of 38 MW which corresponds to a shaft horse-power of 10,000. The reactor installation comprises the pressure container with its built-in units, the surrounding safety container with various installations enclosed in it, the auxiliary installations, the electrical equipment, and parts of the apparatus for fuel handling. Diagrams of the reactor vessel and photographs of the ship and reactor equipment are provided. (BBB)

# Reactor Theory

18756 (ANL-7411(Suppl.3)) ARGONNE CODE CENTER: COMPILATION OF PROGRAM ABSTRACTS. Butler, M. K.; Legan, Marianne; Ranzini, L.; Snow, William J. (Argonne National Lab., Ill.). Oct 1969. Contract W-31-109-eng-38. 203p. Dep. CFSTI.

Additional and revised material is presented on the Argonne compilation of computer program abstracts. The majority of the programs treat various aspects of nuclear physics or reactor physics. The program abstracts are classified by subject area, and a KWIC index is included. (H.D.R.)

## Kinetics

*Refer also to abstracts 16858, 16859, 18616, 18618, 18697, 18699, and 18787.*

18757 (ANL-7627) FUNCTIONALS FOR FLUX SYNTHESIS WITH DISCONTINUOUS TRIAL FUNCTIONS. Lambropoulos, P.; Luco, Victor (Argonne National Lab., Ill.). Oct 1969. Contract W-31-109-eng-38. 23p. Dep. CFSTI.

It is shown that the functionals originally used in variational flux synthesis with continuous trial functions can also be used with discontinuous functions, provided they are modified so as to yield physically meaningful stationarity conditions at the discontinuity interfaces. It is furthermore demonstrated that various functionals proposed in the past for such use are equivalent, without any among them having any added validity. Some mathematical difficulties that had been attributed to the use of discontinuous trial functions are clarified and shown to have been the result of inappropriate calculational methods. 11 references. (auth)

18758 (CONF-690910-, pp 473-90) SYSTEM FOR CALCULATION OF FISSION POWER IN IRRADIATION TESTS. Lieberman, Richard M. (Bettis Atomic Power Lab., Pittsburgh, Pa.).

A system has been developed which will predict fission power for irradiation test fuel samples. The samples are irradiated in a relatively stable, standard environment. Within this environment test fission power is controlled. The effect of system variables on fission power, determined by neutron diffusion and transport theory, was reduced to a set of design curves. Effective neutron fluxes are found from these design curves. Time dependent nuclear depletion equations are then solved for the isotopic content of both fertile and non-fertile test fuel materials. The system has been verified in the ETR. 3 references. (auth)

18759 (CONF-690910-, pp 698-732) A DOUBLY TELESCOPING DESIGN OF A NUCLEAR REACTOR EXPERIMENT CONTAINING EIGHT VARIABLES. Sheibley, Dean W.; Holms, Arthur G.; Sidik, Steve M. (National Aeronautics and Space Administration, Cleveland, Ohio. Lewis Research Center).

A blocked two-level factorial experiment was designed to measure the pressure buildup due to radiolysis of water. Effects of controlled variables are influenced by changes in radiation environment with time and by equipment changes between groups of reactor cycles; the experiment is therefore doubly confounded. Experimenting is subject to unplanned curtailments with respect to the second. So that the more important parameters can be estimated free of biases ordinarily resulting from the indefinite size of the experiment, the rationale is given for arranging the blocks of the experiment in a "doubly telescoping" (orthogonally blocked) sequence. 6 references. (auth)

18760 (EIR-164) SEMIANALYTIC SOLUTION OF THE TIME- AND PLACE-DEPENDENT NONLINEAR XENON PROBLEM. Auerbach, T.; Mennig, J.; Gujer, E. (Eidgenoessisches Institut fuer Reaktorforschung, Wuerenlingen (Switzerland)). Oct 1969. 33p. (In German). Dep. CFSTI (U. S. Sales Only).

The space-dependent xenon problem of reactor theory leads to a series of non-linear partial differential equations, which cannot be solved exactly. All previous treatments of the problem represent approximations with linear differential equations. Presented is a relatively simple semianalytic method in which the space variable is divided into discreet steps. The corresponding differential equations with respect to time are developed and analytically integrated. (H.B.G.)

18761 (EUR-4385) THREE-DIMENSIONAL CALCULATION OF POWER DENSITIES AND TEMPERATURES IN A GAS-GRAPHITE REACTOR. Final Report. Pages, M.; Picou, J. L.; Veilhan, G. (Groupement Atomique Alsacienne Atlantique, Le Plessis-Robinson (France)). 4 Feb 1969. 226p. (In French). Dep. CFSTI (U. S. Sales Only). EUR.

The flux values and the efficiencies of control rods partly inserted in a gas-graphite power reactor are determined analytically by a method derived from that of Nordheim-Scalettar. The scheme adopted is that of a cylindrical homogeneous reactor, axially bare, with two multiplier zones and a radial blanket, and the analysis is done by means of an expansion in axial harmonics. After determination of the reactivity of the individual components, characterized by their extrapolation distances, the temperatures are deduced from the local thermal flux normalized to the total reactor power. Two codes (MUTHER I and II), differing essentially in approximations to the heterogeneity boundaries, and the associated code (BARCEL) for calculating the extrapolation distances, were written in FORTRAN IV and perfected on the Ispra JRC's IBM 360/65 machine. A comparison was made with the values measured on the Italian Latina power reactor and French EDF-2 reactor. The differences between the theoretical and experimental values (a few per cent on the gas heating values) show that these codes give satisfactory results. (auth)

18762 (FMRB-5/69) A FORTRAN PROGRAM "STABFALL". Hollnagel, R. (Physikalisch-Technische Bundesanstalt, Brunswick (West Germany)). Apr 1969. 12p. (In German). Dep. CFSTI (U.S. Sales Only).

At the time $t_0$ a control rod is inserted suddenly into a stable and critical reactor. Decrease of the thermal neutron flux is then

considered for 60 different time intervals. Delayed neutrons are multiplied by a correction factor to account for the difference in energy distribution in comparison with prompt fission neutrons. Mathematical formulas for the problem are developed. Finally, a computer program for solution of the equations is present. (H.B.G.)

18763 (KAPL-P-3869) INCLUSION OF TWO-DIMENSIONAL SPECTRAL EFFECTS IN FEW-GROUP CELL CALCULATIONS. Crawford, B. W.; Friedman, J. P.; Merriman, F. C. (Knolls Atomic Power Lab., Schenectady, N. Y.). [1969]. Contract W-31-109-eng-52. 30p. (CONF-691102-21). Dep. CFSTI.

From 17th Conference on Remote Systems Technology, San Francisco, Calif.

The use of two-dimensional diffusion theory spectra to obtain few-group neutron cross sections for transport-theory eigenvalue calculations is discussed. The calculations, using the IT program, describe the spatially dependent reaction rates within a 1/v-absorber plate surrounded by fuel and water. Results of both the cross section calculation and flux synthesis are tabulated. The trial spectra used to establish the spatially dependent spectra are shown graphically. Eigenvalues computed by variational synthesis techniques and Monte Carlo techniques are compared. (M.L.S.)

18764 (RPI-328-184) CONTINUOUS SLOWING DOWN THEORY EXTENDED TO INELASTIC REGION. Becker, Martin; Burns, Edward T. (Rensselaer Polytechnic Inst., Troy, N. Y. Dept. of Nuclear Science). [10 Mar 1970]. Contract AT(30-1)-328. 13p. Dep. CFSTI.

The continuous slowing down theory equations for inelastic scattering is developed for fast reactor analysis. A separable kernel is assumed for the overall slowing down problem and constraints on the kernel are defined. Results of calculations with the continuous slowing down model are compared with $MC^2$ calculations. Effects of energy-dependent neutron-cross-section variations on the slowing down parameters are evaluated. 11 references. (M.L.S.)

18765 (SRRC-32/69) ANALYSIS OF THE $^{135}Xe$ CONCENTRATION IN CYCLICALLY OPERATED NUCLEAR REACTORS. Riley, J. A.; Scobie, J. (Scottish Research Reactor Centre, East Kilbride (Scotland)). Sep 1969. 23p. Dep. CFSTI (U. S. Sales Only).

The detailed theoretical solution for the core $^{135}Xe$ concentration in nuclear reactors working on a cyclic basis is presented. Also included are copies of the Fortran V computer programs used to evaluate the final solution for the different cycle times, operation times, and neutron flux levels assumed. (2 references) (auth)

18766 (ZJE-56) EVALUATION OF CELL PARAMETERS. Vlachovsky, K. (Skoda Concern, Pilsen (Czechoslovakia). Nuclear Power Plants Div.). Oct 1969. 101p. Dep. CFSTI (U. S. Sales Only).

An algorithm for a calculation of square, hexagonal or triangular lattice of a reactor with a cylindrical fuel element is presented. The fuel material is assumed in the shape of rod. The coolant can have the moderating capability. The mathematical model for the calculation of temperature of the neutron gas is presented. The method is made to be applicable for cells of different parameters. 18 references. (auth)

18767 PROBABILITY DISTRIBUTION OF NEUTRON POPULATIONS IN A MULTIPLYING ASSEMBLY. MacMillan, D. B. (General Electric Co., Schenectady, N. Y.). Nucl. Sci. Eng.: 39: 329-36(Mar 1970).

A mathematical method is described for the computation of the probability distribution of neutron populations in a point reactor with a weak source. New formulations for computing the probability distribution from values of the generating function, for evaluating the probability distribution of precursor decay rates instead of that of neutron populations, and for evaluating the effect of short neutron lifetime without using unnecessarily short time steps in numerical integration are presented. As a result, the method presented is more widely applicable and more accurate than the older methods. The reactor model permits taking account of six delayed-neutron precursor groups and of finite neutron lifetime. 6 references. (auth)

18768 COUPLED SAMPLING WITH THE MONTE CARLO METHOD IN NEUTRON TRANSPORT CALCULATIONS. Carter, L. L. (Los Alamos Scientific Lab., N. Mex.); McCormick, N. J. Nucl. Sci. Eng.: 39: 296-310(Mar 1970).

A scheme is devised which combines in a coupled manner the sampling from the transport equation and the adjoint transport equation to improve the sampling for a functional such as the space- and velocity-dependent neutron distribution due to a given source distribution. Specific use is made of sampling for the transport equation to construct a scheme for a near-optimal subsequent sampling from the adjoint equation, even when inelastic scattering is present. The energy-dependent reciprocity relation is utilized to relate the solution of the adjoint equation to that of the transport equation itself. This procedure may be expected to be advantageous when the phase-space volume contributing to the functional in the region of interest is smaller than that volume in the source region. Numerical results demonstrate that calculation times in two example problems can be significantly reduced with the coupled sampling approach. 19 references. (auth)

18769 MATHEMATICAL MODEL FOR ANALYZING EFFICIENCY OF NUCLEAR FUEL CYCLES. Haiduc, C.; Szmuk, Al. Stud. Cercet. Energ. Electrotch.: 18: 741-52(1968). (In Rumanian).

The mathematical model for analyzing the efficiency of nuclear fuel cycles is presented. The model is applicable to any kind of thermal reactor with one or several active zones for simple fuel loads or for a large number of partial loads. The model was used on 11 kinds of 600 MW nuclear power stations considered independently and for their over-all life-times, as well as on 10 thermal and fast breeder reactors within the future nuclear power development plan. (auth) (Rom. Sci. Abstr.)

18770 FLOW-TECHNOLOGICAL STUDY OF THE ROTATING REACTOR MODEL. Sarkany, Antal (Inst. for Isotopes, Budapest). Kem. Kozlem.: 32: No. 2, 129-32(25 Oct 1969). (In Hungarian).

A laboratory reactor model is described in which homogeneous, liquid-phase reactions can be realized under either isothermal or adiabatic conditions, with continuous operation, and where the residence time distribution function that characterizes the flow properties can be varied between the perfectly mixed and completely segregated states. The model involved the rotating tubular reactor. The mixing in the reactor was characterized by a fictitious parameter, the so-called mixing unit value. The value equals the equivalent cascade number: if its value is known, then the reactor may be simulated with an equivalent cascade reactor for the purposes of studying the flow processes. The reactor is described. The residence time spectrum is determined with the aid of isotopes. 4 references. (JPRS)

18771 SPACE-TIME NUCLEAR REACTOR KINETICS. Stacey, Weston M. Jr. Nuclear Science and Technology. Volume 5. A Series of Monographs and Textbooks. New York; Academic Press Inc. (1969). 193p. $13.00.

Theoretical and computational methods for solving reactor kinetic equations are described. Equations and techniques are developed using spatial approximations, numerical integration methods for time dependence, variational synthesis methods, stochastic kinetics, xenon spatial oscillations, stability, and control. The derivation of multigroup diffusion equations is detailed in the appendix. (M.L.S.)

18772 INHERENT STABILITY OF NUCLEAR REACTORS WITH APPLICATION TO FAST REACTORS. Josephson, Jules. Pittsburgh; Carnegie-Mellon Univ. (1969). 264p.

Thesis.

The inherent stability problem of nuclear reactors is formulated in a comprehensive manner. The asymptotic stability of fast reactors in the operating state when stability in the first approximation holds has been investigated. A mixed lumped parameter model with three simple flow dependent delays has been shown to account for the resonance instability and tendency toward low frequency resonance in fast reactor response. The long time constant delay has been attributed to a thermal relaxation time in the blanket. Data obtained from EBR-1, Dounreay and Fermi reactor oscillator tests are analyzed. The stability of the critical case when the reactor motion depends only upon the nonlinear terms has been analyzed for simple models using the method of Liapunov. The possibility of finite escape time type solutions is discussed. It is shown that for a positive first order reactivity coefficient, finite escape times are possible, but that higher order reactivity effects which must be present limit the excursion or shut the reactor down. The conditions for Lagrange stability when a prompt negative reactivity coefficient is present are derived using theorems due to R. K. Miller applied to the reactor kinetics equations in the form of a nonlinear integro-differential equation with a "hereditary" term. The condition for promptness of a reactivity coefficient is derived. This condition is applied to mixed oxide fuels where the effect of a delayed Doppler coefficient must be considered. (Diss. Abstr.)

18773 CRYSTALLINE-BINDING EFFECTS ON REACTOR PHYSICS PARAMETERS. Weinreich III, William Arthur. Pittsburgh, Pa.; Carnegie-Mellon Univ. (1969). 192p.

Thesis.

Crystalline binding effects on reactor physics parameters are determined for reactor systems in which BeO is the moderator. The accuracy of the crystalline binding representation needed to properly account for crystalline effects is also determined. The incoherent approximation is made for both elastic and inelastic scattering of neutrons. The differential scattering cross section is expressed in terms of the scattering law formalism. Lattice dynamics models for BeO are analyzed. Scattering kernels are calculated for the three models chosen to represent the crystalline binding. Eigenvalue calculations are performed for a homogeneous system of $PuO_2$-BeO and a cylindrical lattice system of $UO_2$-$PuO_2$-BeO. The results of these calculations show the inadequacies of representing crystalline binding by the affective temperature gas model and the lattice dynamics model of Debye. (Diss. Abstr.)

**18774** SOLUTION OF CRITICAL PROBLEMS IN ASYMPTOTIC APPROXIMATION. Shulepin, V. S. At. Energ. (USSR); 28: 60-1(Jan 1970). (In Russian).

The asymptotic theory was used for reactor criticality calculations with multigroup assumption. (6 references) (R.V.J.)

**18775** SOLUTION OF CRITICAL PROBLEMS BY SOLVING NONLINEAR EQUATIONS. Shulepin, V. S.; Rumyantsev, G. Ya. At. Energ. (USSR); 28: 61-2(Jan 1970). (In Russian).

A multigroup method (with arbitrary number of energy groups) for reactor criticality calculations is described considering the properties of the medium as continuous coordinate functions. 5 references. (R.V.J.)

**18776** VARIATIONAL TECHNIQUES AS A METHOD FOR MULTIDIMENSIONAL REACTOR CALCULATIONS. Steele, Myrna L. (Div. of Technical Information Extension, Oak Ridge, Tenn.). Reactor Technol.; 13: 73-95(Winter 1969-70).

References on applications of variational synthesis techniques to the neutron diffusion and transport equations used in reactor physics calculations are summarized. The references cited represent publications for the period 1966 to June 1969. The principles of variational synthesis methods are defined, and numerical examples are presented to illustrate the applications of these techniques. 25 references. (H.D.R.)

**18777** PROBABILITY DISTRIBUTIONS IN SIMPLE NEUTRONIC SYSTEMS VIA THE FOKKER-PLANCK EQUATION. Williams, M. M. R. (Queen Mary Coll., London). J. Nucl. Energy; 23: 633-42(Dec 1969).

The Fokker–Planck equation for the neutron density probability distribution in a multiplying system, possessing random source and random parametric excitation, is deduced. It is shown that white noise parametric excitation and white noise source excitation both have the same effect on the functional form of the correlation but that the parametric excitation increases its amplitude. A method for obtaining the correlation function directly from the conditional probability distribution is described and applied to a simple point model equation with one group of delayed neutrons. (auth)

**18778** THE NUMERICAL SOLUTION OF THE SPACE-TIME REACTOR KINETICS EQUATIONS USING AN ALTERNATING-DIRECTION EXPLICIT PROCEDURE. Iyer, Shrinivas Shankar. Columbus, Ohio; Ohio State Univ. (1969). 156p.

Thesis.

A method of numerical solution of the space-dependent reactor kinetics equations is described for analysis for multidimensional cores. The method is termed the Alternating Direction Explicit Procedure (ADEP). The Alternating Direction Explicit Procedure is a nodal method for solving a set of difference equations obtained from the space-dependent reactor kinetics equations. The technique combines the best features of explicit and implicit methods. The space-dependent reactor kinetics equations are considered for two energy groups, one delayed group and no reactivity feedback. The Alternating Direction Explicit Procedure is shown to be an unconditionally stable explicit finite difference scheme in its application to the space-dependent reactor kinetics equations with the alternating direction feature reducing the truncation error for the numerical technique from the first to second order in $\Delta x$. Computer codes based on the numerical technique are described. The accuracy of the method is evaluated by comparing ADEP code results with those of an analytical solution for a bare homogeneous core. It is seen that the running times of GAKIN and WIGL2 and ADEP are comparable. However, GAKIN and WIGL2 cannot be extended directly to multi-dimensional and multigroup problems. Because the approximation in the ADEP method occurs in the Laplacian term, the truncation error in time increases as the mesh size decreases. (Diss. Abstr. Int., B)

## Dynamics

*Refer also to abstracts 18615 and 18622.*

**18779** (BNWL-1229) COBRA-II: A DIGITAL COMPUTER PROGRAM FOR THERMAL-HYDRAULIC SUBCHANNEL ANALYSIS OF ROD BUNDLE NUCLEAR FUEL ELEMENTS. Rowe, D. S. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Feb 1970. Contract AT(45-1)-1830. 60p. Dep. CFSTI.

The COBRA-II program calculates the steady-state flow and enthalpy in the subchannels of rod bundle nuclear fuel elements during both boiling and nonboiling conditions. The program uses a mathematical model that includes the effects of turbulent and diversion crossflow mixing between the subchannels. Turbulent crossflow mixing is caused by lateral flow fluctuations between subchannels and diversion crossflow mixing is caused by flow redistribution resulting from changes in the axial pressure gradient or from forced crossflow. The equations of the mathematical model are solved as an initial-value problem by using finite differences. The solution of the equations for flow, enthalpy, pressure and diversion crossflow must rely on input correlations to specify the turbulent crossflow and subchannel pressure gradient. The program is designed to allow the user to select these correlations to best fit his particular application. Besides having a faster and a more accurate numerical solution than in the original version of COBRA, COBRA-II has new features to improve its versatility. It can include the effect of subcooled voids. Subchannels may be typed so that nonuniform hydraulic behavior can be considered. Distorted bundles may be analyzed by selecting variable subchannel areas and gap spacings along the length. Spacer pressure loss and forced diversion crossflow can be considered. Turbulent mixing without boiling may be specified by several different correlation forms. During boiling, the mixing correlation for nonboiling can be used or turbulent mixing may be given as a function of steam quality. Adjustable dimensions are included in COBRA-II to allow the user to expand or contract the size of the program to accommodate his computer storage capability. The program has performed successfully with 36 subchannels, 25 fuel rods and 60 subchannel connection. 14 references. (auth)

**18780** BOUNDEDNESS AND STABILITY OF SOME MODELS OF NUCLEAR REACTORS. Smets, Henri B. (Univ., Liege). Nucl. Sci. Eng.; 39: 289-95(Mar 1970).

Two new properties of the reactor dynamics equations are derived. If the impulse response of the feedback is positive, the power remains bounded. If in addition $\mathrm{Re}\{(1/\bar{Z}) + n_0 [\bar{K} - \bar{K}(0)]\} > 0$, the power is asymptotically stable. 12 references. (auth)

**18781** THE ROLE OF RADIATION HEAT TRANSFER IN A GAS-COOLED FAST REACTOR. Stoddard, James Alvin. Seattle; Univ. of Washington (1969). 176p.

Thesis.

The importance of thermal radiation in the coolant and fuel of a conceptual design for a gas cooled fast breeder reactor is discussed. A numerical procedure which is capable of analyzing both the steady-state heat transfer in the fuel and the entrance region heat transfer in the coolant is described. This numerical procedure consists of the simultaneous solution of the energy conservation equation, the Fourier conduction equation, and the linear Boltzmann equation, and the treatment of turbulent convection by the eddy diffusivity method. The energy and conduction equations are solved by standard difference techniques, and the Boltzmann equation is solved by the $S_N$ discrete ordinates method of neutron transport theory. It is shown that the optically thick limit of the Boltzmann equation gives a good representation of the heat transfer in the polycrystalline fuel, although the small error is nonconservative. Several conduction-radiation model problems in one-dimensional plane, cylindrical, and spherical geometries are performed for comparison with the solutions of diffusion theory and with the published results of other authors. (Diss. Abstr. Int., B)

## Experimental Applications

*Refer also to abstracts 18648, 18728, and 18729.*

**18782** (RISO-M-1204) EXPERIMENTAL DETERMINATION OF THE $^{238}U$ EXCESS RESONANCE NEUTRON CAPTURE INTEGRALS OF THREE CLUSTERED FUEL ELEMENTS. Buck, W. Ch. (Danish Atomic Energy Commission, Risoe. Research Establishment). Jan 1970. 12p. Dep. CFSTI (U. S. Sales Only).

A two-spectrum method was used to measure the excess resonance neutron capture integral of $^{238}U$ in three different fuel ele-

ments: The first element contained nineteen U-metal rods and was $D_2O$ cooled, the second and third consisted of fifteen $UO_2$ rods and were cooled by heavy water and air respectively. The measurements were performed in an exponential experiment. (7 references. (auth)

18783 (WAPD-TM-915) A MEASUREMENT OF NEUTRON SPATIAL DISTRIBUTION IN A WATER MODERATED, THORIUM OXIDE ROD LATTICE (LWBR DEVELOPMENT PROGRAM). Beilin, P. B. (Bettis Atomic Power Lab., Pittsburgh, Pa.). Feb 1970. Contract AT(11-1)-Gen-14. 40p. Dep. CFSTI.

A large lattice of Zircaloy-4 rods filled with $ThO_2$ pellets and completely submersed in water was used to test the cross sections of $ThO_2$, $H_2$, and Zr. The spontaneous fissions from 5 micrograms of $^{252}Cf$ provided the source neutrons. Cd covered In foils within the rods detected the neutrons up to 35 centimeters from the source. The measured foil activations were subsequently modified to correspond to activations by the main 1.458-ev indium resonance alone. This measured distribution was then compared to the predictions of a 3-D Monte Carlo calculation. As the distance from the source increased, the measured distribution decreased significantly slower than the Monte Carlo predicted distribution. 31 references. (auth)

18784 FAST-REACTOR-CORE DESIGN OPTIMIZATION BY LINEAR PROGRAMMING. Inoue, Kotaro (Hitachi Ltd., Kawasaki, Japan). Nucl. Sci. Eng.; 39: 394-8(Mar 1970).

Although fast reactor cores have so far been optimized by calculating fuel-cycle cost as a few parameters were changed systematically, the best design cannot be obtained with such partial optimization. It is shown that the best design, considering most of the core-characterizing parameters, some of which may have constraints, can be obtained through the use of linear programming. The merit of linear programming is the ease of dealing with many variables. Moreover, effects of the changes of the constraints, the design limits in this case, on the cost of power generation can also be determined. On the other hand, the disadvantage of this method is the error introduced by the linear approximations. This error will be small, however, if the reference design point was properly chosen. The process and results of design optimization by this method using a 300 MW(e) fast reactor as an example are presented. 9 references. (auth)

## Reactor Components, Fuels, and Accessories

*Refer also to abstracts 16419, 16464, 16648, 16649, 16736, 16738, 16741, 16755, 16769, 16770, 16784, 16805, 16809, 16814, 16832, 16914, 16924, 16936, 17190, 17191, 17193, 17194, 17223–17226, 17236, 17274, 17275, 17291, 17292, 17294, 17332, 17344–17346, 17349, 17354, 17356, 17360, 17376, 17378, 17379, 17388–17391, 17393, 17396, 18581, and 18582.*

18785 (CONF-690910–, pp 118-26) UNRESTRAINED SWELLING AND FISSION GAS RELEASE EXPERIMENTS. Montgomery, Michael H.; Grando, Carl J.; Strasser, Alfred A. (United Nuclear Corp., Elmsford, N. Y.).

Illustrations and design parameters of radiation target cans designed for swelling studies of mixed carbide fuels are presented. Operating conditions and experimental results are included. (D.C.C.)

18786 (CONF-690910–, pp 435-45) POST-IRRADIATION ANALYSIS OF HIGH TEMPERATURE, LOW BURNUP TUNGSTEN–$UO_2$ TEST PLATES. Ball, L. L.; Sheibley, D. W. (National Aeronautics and Space Administration, Cleveland, Ohio. Lewis Research Center).

Problems in determining fuel burnup of high temperature fueled plates were resolved by using $^{184}W$ as a thermal flux monitor. Methods for determining fission product releases from fueled test plates were evaluated. The use of fission product $^{137}Cs$ as a burnup monitor was also evaluated. 2 references. (auth)

18787 (CONF-690910–, pp 446-65) DECAY HEAT GENERATION AND REMOVAL FROM FUEL TEST BUNDLES. Daugherty, H. F.; Lieberman, R. M.; Doumas, M. (Bettis Atomic Power Lab., Pittsburgh, Pa.).

Simplified calculational techniques have been developed for estimating the decay heat power levels for irradiated fuel specimens, as a function of operating heat flux and effective full power days of operation. The calculated decay heat values were experimentally verified. Specimen surface temperatures have been measured in typical small test bundles exposed to stagnant air cooling. 4 references. (auth)

18788 (CONF-690910–, pp 583-94) CRICET, A SYSTEM FOR REMOTE MEASUREMENT OF FUEL-ELEMENT TEMPERATURES. Buck, J. S. (Atomics International, Canoga Park, Calif.).

The CRICET system has been devised to remotely monitor temperature distributions within individual experimental fuel elements located in fast and thermal reactor cores. The system design is unique in that no in-vessel instrumentation leads or vessel penetrations are used to accomplish this function. Self-contained compact transmitter units are included within the structures of individual fuel elements. During reactor operation the transmitter sends a pulsed acoustic signal, with a pulse frequency proportional to the temperature measured, to acoustic pickups and noise analysis instrumentation outside the vessel. (auth)

18789 (EURFNR-683) A HYDRAULIC/PNEUMATIC DEVICE FOR INDICATING THE POSITION OF A CONTROL ROD IN A NUCLEAR REACTOR. Muehlhaeuser, O. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Reaktorbauelemente). Translation of report KFK-951. 36p. Dep. CFSTI.

Work Performed under United States–Euratom Fast Reactor Exchange Program.

A control rod position indicator is described. The indicator device is independent of the actual control rod system. The reactor coolant medium is used to actuate the indicator. The indicating device consists of a hydraulic bridge circuit with four branches. Two of the branches are variable and are a function of the displacement path of the control rod. The required pressure drop for the operation of the bridge is created by a reduction of the reactor pressure tapped off and is maintained at a constant value by means of a regulator. Design parameters are presented. (D.C.C.)

18790 (GA-9488) PRESTRESSED CONCRETE REACTOR VESSEL ANALYTICAL METHODS DEVELOPMENT. Final Progress Report, July 1, 1968–June 30, 1969. Rashid, Y. R. (Gulf General Atomic, Inc., San Diego, Calif.). Jul 1969. Contract W-7405-eng-26; Subcontract No. 2848. 25p. Dep. CFSTI.

For Union Carbide Corp., Nuclear Div., Oak Ridge, Tenn.

CONCRETES—stress analysis of prestressed, comparisons of computer program calculated and model measured, (E/T)

PRESSURE VESSELS—development of prestressed concrete, during July 1968 to June 1969, (E/T)

—stress analysis of prestressed concrete, comparison of computer program calculated and model measured, (E/T)

REACTORS—pressure vessels for, development of prestressed concrete, (E/T) (D.L.C.)

18791 IMPROVEMENTS IN OR RELATING TO NUCLEAR REACTOR FUEL ELEMENTS. Cocker, P.; McCrerie, Alan Ian (to United Kingdom Atomic Energy Agency). British Patent 1,179,844. 4 Feb 1970. Filed 27 Apr 1966.

Reference is made to fuel elements of the cluster type comprising sheathed fuel rods supported in parallel spaced relationship. The mode of securing the rods must be such that they can be readily removed from the support grids for chemical reprocessing. In the fuel element described the rods are secured at one end to a support grid by spring means on the grid, this spring means releasably engaging with an end portion of each fuel rod in such a manner that the fuel rods are restrained against axial movement relative to the support grid. Transference of the weight of the fuel rods to the support grid may be effected by positive engagement between parts not involving the spring means, the latter being employed for releasably retaining the fuel rods in the position of positive engagement. (UK)

18792 NUCLEAR REACTOR. Cook, Reginald Kenneth; Deacon, David (to Nuclear Design and Construction Ltd.). British Patent 1,178,161. 21 Jan 1970. Filed 10 Jan 1967.

Reference is made to reactors of the kind having at least one pressurised interval circuit which is adapted to be serviced during reactor operation by a servicing machine via at least one tubular standpipe, which has a closure plug with locking means. In this system described secondary locking means are provided for the closure plug comprising at least one latch member mounted adjacent to or on the standpipe and adapted to be biased to a latching position in which it projects into the bore of the standpipe when the servicing machine is not in use. This provides a stop for preventing the plug from being blown out of the standpipe should the primary locking means fail. The latch member is profiled and the arrangement is such that, during a closure plug withdrawal operation, the servicing machine nose unit is moved to engage the standpipe and the latch member. The latter is then urged against its bias out of the bore of the standpipe so as to release the secondary locking means prior to release of the pri-

mary locking means. Various alternative designs of latch members are described. (UK)

**18793** DRIVE AND COUPLING MECHANISMS FOR NUCLEAR REACTOR CONTROL ELEMENTS. (to Combustion Engineering, Inc.). British Patent 1,182,239. 25 Feb 1970. Priority date 10 Oct 1967, United States.

REACTOR CONTROL ELEMENTS—drive mechanism for, with means for remote operation of coupling gripper (H.D.R.)

**18794** SAFETY ASSESSMENT OF AUTOMATIC AND MANUAL PROTECTIVE SYSTEMS FOR REACTORS. Green, A. E. (United Kingdom Atomic Energy Authority, Risley, Eng.). Instrum. Pract.; 109-13(Feb 1970).

The factors governing the assessment of both automatic and manual actions in a protective system for a nuclear reactor are discussed. An equipment is described which produces signals which are reasonably representative, both in form and in time distribution, of certain types of reactor fault indications. Measurement is made of the time interval between the onset of the signal and the operator's acceptance or cancellation of the signal. Results of tests using the equipment are reported and the method of result analysis discussed. (UK)

**18795** DEVICE FOR PROTECTING THE INVERTER CIRCUIT FOR DRIVING REACTOR CONTROL RODS. Sato, Takao (to Hitachi Ltd.). Japanese Patent 1969-23566. 7 Oct 1969. Filed 19 Mar 1965.

A device is proposed for protecting the inverter circuit in the control-rod drive. The device includes the following: a circuit, installed between the converter and inverter circuits, for detecting excess current flowing from the former to the latter circuit; a comparison circuit, which gives an output when the detected excess-current exceeds the set value in current-setting circuits; a uni-stable multivibrator, triggered by the comparison circuits, which operates an automatic pulse phase device for the gate control of a silicon control rectifier in the converter circuit and triggers the bi-stable multi-vibrator circuit having a pre-setting; and a relay, controlled by the bi-stable multi-vibrator circuit. By means of the relay, the power source for a control-rod driving motor is selected between the inverter and the converter circuits. (NSA of Japan)

**18796** FUEL ELEMENT FOR NEUTRONIC REACTOR AND METHOD OF FABRICATION THEREOF. (to United States Atomic Energy Commission). British Patent 1,183,180. 4 Mar 1970. Priority date 29 Mar 1968, United States.

REACTOR FUEL ELEMENTS—fabrication of interconnected parallel arranged vented pin type, method for (D.C.C.)

**18797** NUCLEAR FUEL CO. TO TAKE OVER FUEL JOBS IN THE U.K. Com. Naz. Energ. Nucl., Notiz.; 16: 59-64(Jan 1970). (In Italian).

A nuclear fuel concern is to be established in the United Kingdom. It will take over the fuel activities so far handled by the U.K. AEA production group. (auth)

**18798** NUCLEAR REACTOR CONTROL ROD GRIPPING APPARATUS. Bertone, Louis A. (to Combustion Engineering, Inc.). U. S. Patent 3,486,974. 30 Dec 1969. Filed 10 Oct 1967.

A coupling device adapted especially for connecting a nuclear reactor control rod to its drive mechanism is described. The device releasably connects the control rod to the control rod-operating or ram portion of the drive mechanism. It includes a hollow body having a receptacle into which a retention head on the control rod is inserted. Surfaces within the receptacle form a shoulder engageable with a mating shoulder on the retention head upon relative rotation between the coupling assembly and the control rod. A releasable, spring biased latch member is provided to secure the members in coupled relation. (Offic. Gaz.)

**18799** UNIT FOR AUTOMATIC PRECISION GUIDING OF A NUCLEAR REACTOR CHARGING MACHINE. Skoda Rev.; No. 4, 63-4(1968).

A system developed by Skoda for moving and precision positioning of a loading machine is briefly described. The unit is remote-controlled and can be operated both manually and automatically. (H.D.R.)

**18800** UTILIZZAZIONE DEL COMBUSTIBILE NUCLEARE. Atti delle Giornate dell'Energia Nucleare, Milano, 12-14 Dicembre 1968. (Utilization of Nuclear Fuel. 10th International Nuclear Energy Conference, Milan, December 12-14, 1968). Serie Simposi. Roma; Comitato Nazionale Energia Nucleare (1969). 373p. (In Italian and English). (CONF-681219).

Topics related to nuclear fuel fabrication, utilization, and reprocessing are discussed. Separate abstracts are included for 15 of the 19 papers presented. Four papers have been previously abstracted and can be located in the NSA Report Number Index under: CONF-681219. (D.C.C.)

*For abstracts of individual papers see: 16716–16718, 16799–16801, 16824, 17354, 18554, 18662–18665, 18801, and 18802.*

**18801** FUEL CYCLE: CARRYING OUT OF THE CNEN PROGRAM. Salvetti, C. pp 23-33 of Utilizzazione del Combustibile Nucleare. Roma; Comitato Nazionale Energia Nucleare (1969). (In Italian).

From 10th International Nuclear Energy Conference, Milan, Italy. See CONF-681219.

The object of CNEN's activities in the field of the fuel cycle is the creation of an advanced nuclear-industry capability, providing a body of national know-how, and therefore an alternative to the licensing system. This research effort is not intended to substitute CNEN for industry, or to promote a nationalistic self-sufficiency program, but rather to offer to the Italian industry a choice of different technological lines, without thereby ruling out the possible forms of international industrial cooperation. (auth)

**18802** FUELS FOR NUCLEAR REACTORS S.p.A. pp 136-9 of Utilizzazione del Combustibile Nucleare. Roma; Comitato Nazionale Energia Nucleare (1969). (In Italian).

From 10th International Nuclear Energy Conference, Milan, Italy. See CONF-681219.

COREN was established under an agreement between FIAT, Breda and Westinghouse, whereby fuel elements will be fabricated in Italy utilizing Westinghouse's know-how and enabling FIAT and Breda to offer complete nuclear power plants, inclusive of the first core and subsequent recharges. An outline of proposed services is presented. (auth)

# GENERAL

**18803** (ANL–7634) C:WRITE, A REENTRANT ROUTINE TO CONVERT HEXADECIMAL NUMBERS TO EBCDIC DECIMAL. Thalmayer, Conrad E. (Argonne National Lab., Ill.). Nov 1969. Contract W-31-109-eng-38. 37p. Dep. CFSTI.

**18804** (BNL–14393) INFLUENCE OF THE LATENCY FLUCTUATIONS AND THE QUANTAL PROCESS OF TRANSMITTER RELEASE ON THE END PLATE POTENTIALS AMPLITUDE DISTRIBUTION. Soucek, Branko (Brookhaven National Lab., Upton, N. Y.). [1969]. 17p. Dep. CFSTI.

**18805** (BNL–14442) NEW TRENDS IN MULTICHANNEL PULSE DATA ANALYSIS. Soucek, B. Brookhaven National Lab., Upton, N. Y.). [1969]. 45p. Dep. CFSTI.

**18806** (BNL-tr–319) STATISTICAL PHENOMENA IN HETEROGENEOUS SYSTEMS. PROBLEMS IN KINETICS AND CATALYSIS. Roginski, S. Z. (ed.). Translated by Stephen J. Amoretty (Brookhaven National Lab., Upton, N. Y.), from a Publication of the Academy of Sciences, Press, Moscow-Leningrad, 1949. 5p. Dep. CFSTI.

**18807** (COO–1018-1191) A HIGH SPEED ANALOG DIVIDER FOR THE ILLIAC III SCAN SYSTEM. Franco, Sergio (Illinois Univ., Urbana. Dept. of Computer Science). 3 Oct 1969. Contract AT(11-1)-1018. 15p. Dep. CFSTI.

**18808** (COO–1018-1198) STUDIES IN IMAGE PROCESSING: A SYSTEMS VIEWPOINT. Woolfson, Jacob L.; Heider, Charles H. (Illinois Univ., Urbana. Dept. of Computer Science). 12 Feb 1970. 67p. Dep. CFSTI.

**18809** (COO–1269-22) MIXING PROCESS IN SOILS OF SOLUTIONS OF DIFFERENT DENSITIES AND VISCOSITIES. Progress Report. (Iowa State Univ. of Science and Technology, Ames). [nd]. Contract AT(11-1)-1269. 17p. Dep. CFSTI.

**18810** (COO–1354-18) SITE DENSITIES OF SOLID CATALYSTS. Maatman, Russell W. (Dordt Coll., Sioux Center, Iowa. Dept. of Chemistry). [1969]. 19p. Dep. CFSTI.

**18811** (COO–1469-148) QUARTERLY TECHNICAL PROGRESS REPORT, JULY–SEPTEMBER 1969. (Illinois Univ., Urbana. Dept. of Computer Science). 232p. (COO–1018-1193). Dep. CFSTI.

**18812** (COO–1469-151) GRAPHICS 8: GRAPHICS HARDWARE, 1469 GEAR. Carter, C. E.; Hostovsky, R.; Levin, H.; Lopeman, H.; Miller, R. (Illinois Univ., Urbana. Dept. of Computer Science). Dec 1969. Contract AT(11-1)-1469. 82p. Dep. CFSTI.

**18813** (COO–1469-152) DATA DISC CONTROL GRAPHICS 8. Hostovsky, R.; Lopeman, H. E.; Miller, R. (Illinois Univ., Urbana. Dept. of Computer Science). Dec 1969. Contract AT(11-1)-1469. 40p. Dep. CFSTI.

**18814** (COO–1469-154) ORTHOGONALITY RELATIONS FOR CHEBYSHEV POLYNOMIALS. Report No. 373. Jain, M. K.; Chawla, M. M. (Illinois Univ., Urbana. Dept. of Computer Science). Jan 1970. Contract AT(11-1)-1469. 22p. Dep. CFSTI.

**18815** (COO–1489-8) PROGRESS REPORT NO. 5 [ON NICKEL–ALUMINUM ALLOYS], JANUARY 1969–JANUARY 1970. (Wisconsin Univ., Madison). Contract AT(11-1)-1489. 11p. Dep. CFSTI.

**18816** (COO–1629-16) MAGNETIC FIELD EFFECTS ON THE THERMAL CONDUCTIVITY OF $Co[(NH_2)_2CS]_4.Cl_2$. Ni, Chen-Chou (Illinois Inst. of Tech., Chicago). Jan 1970. 123p. Dep. CFSTI. Thesis.

**18817** (COO–1629-17) THERMAL MEASUREMENTS ON SOLIDS BELOW $1^{\circ}K$. Progress Report No. 4. Weinstock, Harold (Illinois Inst. of Tech., Chicago. Dept. of Physics). Feb 1970. Contract AT(11-1)-1629. 16p. Dep. CFSTI.

**18818** (COO–1631-24) STUDIES ON ISOZYMES OF FRUCTOSE-1,6-DIPHOSPHATE ALDOLASE DURING AMPHIBIAN DEVELOPMENT. II. CHARACTERIZATION OF ISOZYMES IN THE EGG OF RANA PIPIENS. Chen, Lee-Jing; Adachi, Kozoburo; Sallach, H. J. (Wisconsin Univ., Madison. Dept. of Physiological Chemistry). [1970]. 35p. Dep. CFSTI.

**18819** (COO–1684-11) CHEMICAL EFFECTS OF NUCLEAR TRANSFORMATIONS, FLASH HEATING, OR FLASH PHOTOLYSIS. Final Report, January 1–September 30, 1969. Kay, Jack G. (Toledo Univ., Ohio. Dept. of Chemistry). Contract AT(11-1)-1684. 4p. Dep. CFSTI.

The reaction of ethanol on alumina and the thermoluminescence and photoluminescence of $KMnO_4$ crystals were studied. (M.C.G.)

**18820** (COO–1714-4) THE SOLID STATE ELECTRICAL PROPERTIES OF PROTEINS AND BIOLOGICAL SYSTEMS. Technical Progress Report, February 16, 1969–February 20, 1970. Rosenberg, Barnett (Michigan State Univ., East Lansing. Dept. of Biophysics). Contract AT(11-1)-1714. 5p. Dep. CFSTI.

**18821** (COO–2034-3) BUCKLING OF THIN PLATES BY CONTINUOUSLY DISTRIBUTED DISLOCATIONS. Oelcer, N. Y.; Mura, T. (Northwestern Univ., Evanston, Ill.). [nd]. 15p. Dep. CFSTI.

**18822** (COO–2056-1) PALEOCLIMATIC INTERPRETATION OF POSTGLACIAL FLUCTUATIONS OF THE BRISTLECONE PINE TREELINE. I. HISTORY OF THE BRISTLECONE PINE TREELINE. Technical Progress Report, June 1, 1969. LaMarche, Valmore C. Jr. (Arizona Univ., Tucson. Lab. of Tree-Ring Research). 23 Feb 1970. Contract AT(11-1)-2056. 4p. Dep. CFSTI.

**18823** (EURAEC–2077) THE RELATIONSHIP OF NITROGEN CONTENT OF AUSTENITIC STAINLESS STEELS TO STRESS CORROSION. Quarterly Report No. 438-17. Clevinger, Gary S. (Virginia Polytechnic Inst., Blacksburg. Dept. of Metals and Ceramic Engineering). Sep 1968. Contract AT(40-1)-3208. 20p. Dep. CFSTI.

Work performed under United States–Euratom Joint Research and Development Program.

**18824** (IS–2242) AUTOMATIC FILE INTEGRITY IN COMPUTER SYSTEMS. Jordan, John R. (Ames Lab., Iowa). Jan 1970. Contract W-7405-eng-82. 8p. Dep. CFSTI.

**18825** (IS–2244) AN IMPLEMENTATION OF A PL/I SYSTEMS PROGRAM WHICH DEMONSTRATES THE FEASIBILITY OF SYSTEMS PROGRAMMING IN A HIGH-LEVEL LANGUAGE. Hedrick, G. E. (Ames Lab., Iowa). Jan 1970. Contract W-7405-eng-82. 45p. Dep. CFSTI.

**18826** (KFK-tr–293) NUCLEAR DATA WORK IN THE SOVIET UNION. Translated by Rosemarie Corssen (Kernforschungszentrum, Karlsruhe, Ger.), from I.A.E.A. Panel on Neutron Data Compilation, Upton, N. Y. 49p. (In German). Dep. CFSTI (U. S. Sales Only).

Separate abstracts were prepared for the three papers included. (J.W.R.)

*For abstracts of individual papers see: 18827–18829.*

**18827** (KFK-tr–293, pp 2-35) EVALUATION OF NUCLEAR DATA IN THE SOVIET UNION. Nikolaev, M. N. Translated from I.A.E.A. Panel on Neutron Data Compilation, Upton, N. Y. (In German). (CONF-690204–3).

The steps in the processing and evaluation of nuclear data in the Soviet Union are described in detail. The compilation of the nuclear data includes the procurement of bibliographic information, information on the research conditions and the processing methods of the experimental data, and finally the representation of the research results on magnetic tape. The group responsible for the evaluation of the nuclear data has the task of developing programs for cross section calculations, establishing necessary corrections to original studies so that valid comparisons can be made, extrapolation and interpolation of data on the basis of theoretical calculations and semiempirical systematics, and establishment of data of a form suitable for application to the calculation of reactor constants. The programs developed for the evaluation of nuclear data are outlined. Specific examples of such evaluations are given. The application of the evaluated data to the calculation of reactors is illustrated and the need for international cooperation is stressed. The use of critical and exponential experiments for the testing and making more precise of nuclear data is discussed. (J.S.R.)

**18828** (KFK-tr–293, 36-44) OBNINSK INFORMATION CENTER FOR NUCLEAR DATA. Zolotukhin, V. G. Translated from I.A.E.A. Panel on Neutron Data Compilation, Upton, N. Y. (In German). (CONF-690204–5).

The function and structure of the Obninsk information center is outlined. The bibliographic activity is indicated, and the function of the center for the gathering of nuclear data is discussed.

The methods used for the assurance of data exchange with other centers are given. The data available at the center, the exchange format for nuclear data, and the future of the center are all briefly considered. (J.S.R.)

18829 (KFK-tr-293, pp 45-9) NECESSITY FOR AN EXTENSIVE AND RAPID EXCHANGE OF DATA ON NEUTRON EXPERIMENTS. Sukhoruchkin, S. I. Translated from I.A.E.A. Panel on Neutron Data Compilation, Upton, N. Y. (In German). (CONF-690204-4).

A review is given of the requirements on the extensive and rapid exchange of data from neutron experiments. The necessary precautions to supply the experimenter sufficiently with results from earlier or current experiments are first considered. The present possibilities for a rapid computer data retrieval were indicated. Some problems in the representations of additional data were reported. (J.S.R.)

18830 (NYO-1480-132) AXISYMMETRIC BUCKLING OF HOLLOW SPHERES AND HEMISPHERES. Bauer, Louis; Reiss, Edward L.; Keller, Herbert B. (New York Univ., N. Y. Courant Inst. of Mathematical Sciences). Dec 1969. Contract AT(30-1)-1480. 102p. (IMM-379). Dep. CFSTI.

18831 (NYO-3658-21) THE ROLE OF PLANKTONIC PROTOZOA IN THE MARINE FOOD CHAIN. Progress Report, June 1, 1969-May 31, 1970. Gold, Kenneth (New York Aquarium, Brooklyn. Osborn Labs. of Marine Sciences). Contract AT(30-1)-3658. 68p. Dep. CFSTI.

18832 (NYO-4038-1) ON THE LABORATORY SIMULATION OF SMALL-SCALE ATMOSPHERIC TURBULENCE. Ludwig, G. R.; Sundaram, T. R. (Cornell Aeronautical Lab., Inc., Buffalo, N. Y.). Dec 1969. Contract AT(30-1)-4038. 63p. (CAL-VC-2740-S-1). Dep. CFSTI.

18833 (ORNL-4476) AN ALIGNMENT PROCEDURE FOR THE KRATKY SMALL-ANGLE X-RAY CAMERA. Anderegg, J. W.; Mardon, P. G.; Hendricks, R. W. (Oak Ridge National Lab., Tenn.). Feb 1970. Contract W-7405-eng-26. 24p. Dep. CFSTI.

A precision alignment procedure has been developed for the Kratky small-angle x-ray camera. This method uses only a proportional counter to measure the x-ray intensity distribution in the incident beam, as opposed to other methods which require fluorescent screens and x-ray film. During the progress of this work, two useful auxiliary alignment slits were also developed. Their use is described in detail. The roles of previously developed vacuum bellows seals and a diffracted beam graphite monochromator in the alignment procedure are discussed. (auth)

18834 (ORNL-TM-2839) WALKER BRANCH WATERSHED PROJECT PROPORTIONAL WATER SAMPLER DESIGN REPORT AND OPERATING MANUAL. Johnson, W. F.; Miller, W. R. (Oak Ridge National Lab., Tenn.). 10 Feb 1970. Contract W-7405-eng-26. 21p. Dep. CFSTI.

18835 (ORNL-tr-1116) NEW PROCEDURE FOR THE SEPARATION OF IRON FROM OTHER ELEMENTS. Rothe, Jul. Wilh. Translated by J. J. Pinajian (Oak Ridge National Lab., Tenn.), from Stahl Eisen; 23: 1052-4(1892). 4p. Dep. CFSTI.

18836 (ORO-3542-7) THE CHEMISTRY OF RUTHENIUM COMPLEXES. Annual Report. Mercer, E. E. (South Carolina Univ., Columbia). [1969]. Contract AT(40-1)-3542. 20p. Dep. CFSTI.

18837 (SC-DR-69-719) INTERLOCKING TWO-PIECE NUT. Dain, F. C. (Sandia Labs., Albuquerque, N. Mex.). Feb 1970. 5p. Dep. CFSTI.

18838 (SC-RR-66-414) LINEAR THEORY OF PIEZOELECTRIC POWER TRANSFORMERS. Stuetzer, O. M. (Sandia Labs., Albuquerque, N. Mex.). Jul 1966. 24p. Dep. CFSTI.

18839 (SC-RR-69-596) APPROXIMATE ANALYTIC EXPRESSIONS FOR THE ATTENUATION OF A TRIANGULAR PRESSURE PULSE WITH DISTANCE. Bertholf, L. D.; Oliver, M. L. (Sandia Labs., Albuquerque, N. Mex.). Feb 1970. 65p. Dep. CFSTI.

18840 (SC-RR-69-803) DYNAMIC MECHANICAL BEHAVIOR OF POLYCRYSTALLINE $Al_2O_3$. Munson, D. E. (Sandia Labs., Albuquerque, N. Mex.). Jan 1970. 30p. Dep. CFSTI.

18841 (SC-T-70-4010) DENSITY OF MOLTEN ALUMINA. Wartenberg, H. v.; Wehner, G.; Saran, E. Translated by Marcel I. Weinreich (Sandia Labs., Albuquerque, N. Mex.), from Nachr. Ges. Wiss. Goettingen, Math.-Phys. Kl., Fachgruppe II; 2: 73-5 (1936). 4p. Dep. CFSTI.

18842 (SC-T-70-4011) INFLUENCE OF THE MAGNITUDE AND SPEED OF PLASTIC DEFORMATION ON THE SEGREGATION OF HYDROGEN IN IRON AND STEEL. Bastien, P.; Azou, P. Translated by Marcel Weinreich (Sandia Labs., Albuquerque, N. Mex.), from Compt. Rend.; 232: 69-71(1951). 4p. Dep. CFSTI.

18843 (SCL-DR-70-13) REFERENCE MANUAL FOR 6612 CONSOLE OPERATIONS WITH MIMIC. McHugh, R. A. (Sandia Labs., Livermore, Calif.). Feb 1970. Contract AT(29-1)-789. 32p. Dep. CFSTI.

18844 (SCL-DR-70-15) LINEAR SYSTEM POLE-ZERO LOCI PLOTS. Humphrey, R. E. (Sandia Labs., Livermore, Calif.). Mar 1970. Contract AT(29-1)-789. 30p. Dep. CFSTI.

18845 (TID-3756) BIBLIOGRAPHIES OF ATOMIC ENERGY LITERATURE. Issued or in Progress During the Period, November-December 1969. (Division of Technical Information Extension (AEC), Oak Ridge, Tenn.). 14p. Dep. CFSTI.

18846 (TID-25361) FLUORESCENCE PROPERTIES OF PYRIDOXAL-5-PHOSPHATE ENZYMES. Progress Report, June 1, 1969-February 1, 1970. (Tennessee Univ., Knoxville. Dept. of Biochemistry). 27 Feb 1970. Contract AT(40-1)-3553. 14p. Dep. CFSTI.

18847 (UCLA-12-764) A POTENTIALLY UNIQUE TYPE OF LIPID STORAGE IN THE MIGRATING PINK SALMON. Robinson, J. Stephen; Mead, James F. (California Univ., Los Angeles. Lab. of Nuclear Medicine and Radiation Biology). [1969]. Contract AT-04-1-GEN-12. 14p. Dep. CFSTI.

18848 (UCRL-18577) EFFECT OF CONDENSATION IN THE BOUNDARY LAYER ON MASS TRANSFER FROM A ROTATING DISK. Omberg, Ronald P. (California Univ., Berkeley. Lawrence Radiation Lab.). Oct 1969. Contract W-7405-eng-48. 180p. Dep. CFSTI.
Thesis.

18849 (UCRL-18865) FOIL THICKNESS DETERMINATION FROM SINGLE CRYSTAL DIFFRACTION PATTERNS. Bell, W. L.; Thomas, G. (California Univ., Berkeley. Lawrence Radiation Lab.). Aug 1969. Contract W-7405-eng-48. 4p. (CONF-690810-3). Dep. CFSTI.
From 27th Annual Electron Microscopy Society of America, St. Paul, Minn.

18850 (UCRL-18995) INFLUENCE OF SURFACE TURBULENCE AND SURFACTANTS ON GAS TRANSPORT THROUGH LIQUID INTERFACES. Springer, Thomas G.; Pigford, Robert L. (California Univ., Berkeley. Lawrence Radiation Lab.). Nov 1969. Contract W-7405-eng-48. 140p. Dep. CFSTI.
Thesis. Submitted by Thomas G. Springer.

18851 (UCRL-19087) INTENSITY ANALYSIS OF LOW ENERGY ELECTRONS DIFFRACTED FROM SINGLE CRYSTAL SURFACES. Farrell, Helen Honora (California Univ., Berkeley. Lawrence Radiation Lab.). Nov 1969. Contract W-7405-eng-48. 227p. Dep. CFSTI.
Thesis.

18852 (UCRL-19089(Rev.)) ELECTRO- AND MAGNETO-OPTICAL EFFECTS. Shen, Y. R. (California Univ., Berkeley. Lawrence Radiation Lab.). Oct 1969. Contract W-7405-eng-48. 27p. (CONF-691111-2). Dep. CFSTI.
From Ceramics Conference, Gainesville, Fla.

18853 (UCRL-19093) SPECTROSCOPIC INVESTIGATION OF SOME HIGH TEMPERATURE SPECIES TRAPPED IN LOW TEMPERATURE MATRICES. Wang, John Ling-Fai (California Univ., Berkeley. Lawrence Radiation Lab.). Oct 1969. Contract W-7405-eng-48. 129p. Dep. CFSTI.
Thesis.

18854 (UCRL-19106) MICROMECHANICS OF FRACTURE OF PEARLITIC STRUCTURAL STEELS. Guest, Peter J. (California Univ., Berkeley. Lawrence Radiation Lab.). Dec 1969. Contract W-7405-eng-48. 149p. Dep. CFSTI.

18855 (UCRL-19107) STRAIN HARDENING OF LONG RANGE ORDERED SILVER MAGNESIUM SINGLE CRYSTAL. Fotoh, Mohamed Osama Aboel (California Univ., Berkeley. Lawrence Radiation Lab.). Dec 1969. Contract W-7405-eng-48. 67p. Dep. CFSTI.
Thesis.

18856 (UCRL-19109) SPECTRA AND KINETICS OF THE HYDROPEROXYL FREE RADICAL IN THE GAS PHASE. Paukert, Thomas Theodore (California Univ., Berkeley. Lawrence Ra-

diation Lab.). Nov 1969. Contract W-7405-eng-48. 119p. Dep. CFSTI.
Thesis.

18857 (UCRL-19112) PHOTOCHEMISTRY OF IODINE. Tellinghuisen, Joel B. (California Univ., Berkeley. Lawrence Radiation Lab.). Nov 1969. Contract W-7405-eng-48. 209p. Dep. CFSTI.
Thesis.

18858 (UCRL-19334) PHYSICAL PROBES OF NERVE MEMBRANE STRUCTURE. Entine, Gerald (California Univ., Berkeley. Lawrence Radiation Lab.). Dec 1969. Contract W-7405-eng-48. 125p. Dep. CFSTI.
Thesis.

18859 (UCRL-19393) BIOELECTRIC ACTIVITY OF NEURONS IN TISSUE CULTURE: SYNAPTIC INTERACTIONS AND EFFECTS OF ENVIRONMENTAL CHANGES. Schlapfer, Werner T. (California Univ., Berkeley. Lawrence Radiation Lab.). Nov 1969. Contract W-7405-eng-48. 157p. Dep. CFSTI.
Thesis.

18860 (UCRL-19430) ELECTROPHORETIC AND CHEMICAL STUDIES ON THE RAT ERYTHROCYTE MEMBRANE INTERFACE. Tenforde, Tom SeBastian (California Univ., Berkeley. Lawrence Radiation Lab.). Dec 1969. Contract W-7405-eng-48. 89p. Dep. CFSTI.
Thesis.

18861 (UCRL-19524) X-RAY CRYSTALLOGRAPHIC STUDY OF CHLOROPHYLL ANALOGUES AND OTHER BIO-ORGANIC COMPOUNDS. Fischer, Mark Samuel (California Univ., Berkeley. Lawrence Radiation Lab.). Dec 1969. Contract W-7405-eng-48. 209p. Dep. CFSTI.
Thesis.

18862 (UCRL-50759) PRELIMINARY STUDIES IN COMPUTER PROCESSING OF OPTICAL EMISSION SPECTROMETER DATA. Langhorst, Arthur L.; Martin, Walter H. (California Univ., Livermore. Lawrence Radiation Lab.). 29 Sep 1969. 30p. Dep. CFSTI.
An optical emission spectrometer has been modified to give output data on punched cards. A set of preliminary computer programs in FORTRAN IV for the CDC-6600 Computer, developed to calculate the concentrations of trace elements in biological ash samples, are presented. These programs include decisions usually made by a spectroscopist during operations of standard calibration and computation of element concentration in unknown samples. The computer output consists of (1) a listing of raw intensity data, (2) calculations of intensity ratios using an internal standard method with blank subtraction, (3) calculations of coefficients for a least-square three-degree polynomial fit to calibration standards, (4) rejection of erratic data by use of statistical testing, (5) CRT plotting of standard curves, and (6) calculations of trace element concentration in samples. Examples are given of input and output formats, and a complete listing of the programs is included. (auth)

18863 (UCRL-50771) COMPOSITION OF HERMITE INTERPOLATORY ROOTFINDING ALGORITHMS. Hindmarsh, Alan C. (California Univ., Livermore. Lawrence Radiation Lab.). 1 Dec 1969. 27p. Dep. CFSTI.

18864 (UCRL-Trans-10431) HYPOTHETICAL TRANS-NEPTUNIAN PLANETS. Kritzinger, H. H. Translated by J. Hawke for Univ. of California Lawrence Radiation Lab., Livermore, from Sterne; 39: No. 1-2, 6-10(1963). 10p. Dep. CFSTI.

18865 (UCRL-Trans-10434) MEASUREMENT OF THE ELECTRON EMISSION WITH A METALLIC-SURFACE MICROSCOPE. Gaukler, Karl H. Translated for Univ. of California Lawrence Radiation Lab., Livermore, from Z. Metallk.; 51: 463-6(1960). 6p. Dep. CFSTI.

18866 (UCRL-Trans-10435) CHANGES IN SOLVENT STRUCTURE AND LUMINESCENCE OF THE RIGID SOLUTIONS (T → S EMISSION AND RETARDED FLUORESCENCE). Martinez, Andre; Dorignac, Dominique. Translated for Univ. of California Lawrence Radiation Lab., Livermore, from J. Chim. Phys.; 66: 817-24(1969). 17p. Dep. CFSTI.

18867 (UCRL-Trans-10440) BUILDING A DAM BY BLASTING. Pokrovskii, G. I. Translated by B. J. Hazzard for Univ. of California Lawrence Radiation Lab., Livermore, from Priroda; 58: No. 10, 74-7(1968). 10p. Dep. CFSTI.

18868 (UCRL-Trans-10443) RAPID ANALYTICAL METHODS FOR THE INVESTIGATION OF METALS AND INORGANIC RAW MATERIALS. XII. DETERMINATION OF TRACE AMOUNTS OF BERYLLIUM IN MINERAL WATERS AND MINERALS. Sulcek, Z.; Dolezal, J.; Michal, J. Translated by Z. Veselska for Univ. of California Lawrence Radiation Lab., Livermore, from Collect. Czech. Chem. Commun.; 26: 246-54(1961). 19p. Dep. CFSTI.

18869 (UCRL-Trans-10444) STEPS INVOLVED IN THE SYNTHESIS OF METHIONINE BY E. COLI. Stavrianopoulos, J.; Jaenicke, L. Translated by Z. F. St-Gallay for Univ. of California Lawrence Radiation Lab., Livermore, from Eur. J. Biochem.; 3: No. 1, 95-106(1967). 40p. Dep. CFSTI.

18870 (UCRL-Trans-10446) SYSTEMS OF QUASILINEAR EQUATIONS AND THEIR APPLICATIONS TO GAS DYNAMICS. Rozhdestvenskii, B. L.; Yanenko, N. N. Translated by F. D. Jones for Univ. of California, Lawrence Radiation Lab., Livermore, from pp 407-35 of Sistemy Kvazilineinykh Uravnenii i ikh Prilozheniya k Gazovoi Dinamike, Science Press, Moscow, 1968. 48p. Dep. CFSTI.

18871 (USC-113-P-22-1) THE EFFECTS OF ELECTRIC AND MAGNETIC FIELDS ON THE NUCLEATION, STRUCTURE, AND RESIDUAL PROPERTIES OF VAPOR DEPOSITED METAL FILMS. Annual Progress Report. Murr, Lawrence E. (University of Southern California, Los Angeles. Dept. of Electrical Engineering). Dec 1969. Contract AT(11-1)-113. 9p. (USCEE-382). Dep. CFSTI.

18872 (USGS-474-63) REPORT OF EXPLORATION PROGRESS, PAHUTE MESA, PERIOD JULY 31, 1966-JANUARY 31, 1968. Special Studies-I-23-16. Orkild, Paul P. (Geological Survey, Denver, Colo.). 1970. Contract AT(29-2)-474. 60p. Dep. CFSTI.